CLIMATOLOGY

OF

THE UNITED STATES,

AND OF THE

TEMPERATE LATITUDES OF THE NORTH AMERICAN CONTINENT.

EMBRACING A FULL COMPARISON OF THESE WITH

THE CLIMATOLOGY OF THE TEMPERATE LATITUDES OF EUROPE AND ASIA.

AND ESPECIALLY IN REGARD TO

AGRICULTURE, SANITARY INVESTIGATIONS, AND ENGINEERING.

WITH

Isothermal and Rain Charts

FOR EACH SEASON, THE EXTREME MONTHS, AND THE YEAR.

INCLUDING A

SUMMARY OF THE STATISTICS OF METEOROLOGICAL OBSERVATIONS IN THE UNITED STATES,
CONDENSED FROM RECENT SCIENTIFIC AND OFFICIAL PUBLICATIONS.

BY

LORIN BLODGET,

AUTHOR OF SEVERAL RECENT REPORTS ON AMERICAN CLIMATOLOGY; MEMBER OF THE NATIONAL INSTITUTE
AND OF VARIOUS LEARNED SOCIETIES.

"When the varied inflections of the Isothermal Lines shall be traced from accurate observations in European Russia and Siberia, and prolonged to the western coast of North America, the Science of Distribution of Heat on the Surface of the Globe will rest on solid foundations."—HUMBOLDT'S *Address before the Imperial Academy of St. Petersburg*, 1828.

PHILADELPHIA:
J. B. LIPPINCOTT AND CO.
TRÜBNER AND CO.; LONDON.
1857.

ANNOUNCEMENT.

In issuing the present work to Subscribers and the public it is proper to say a word of our guaranties in the prospectus under which subscriptions and orders were invited. The proposed work was necessarily regarded as one standing in a position intermediate between the Transactions of Learned Societies, and those works of popular interest which are controlled by the usual business considerations alone in regard to publication. For this reason the Author was empowered to avail himself of our guaranties in placing it on a basis of support which would warrant the requisite superiority of scientific execution, and the novel character of the matter clearly required such pre arrangements in justice to all parties.

The work, as completed, we believe will be found to meet the fullest promise of our circulars, and in many respects to far exceed those assurances. The engravings are of an unusual character, and for a work issued at the cost to the public of a volume of moderate proportions without large plates, they will not fail to answer all just expectations. Such illustrations are new to other publications than those of scientific societies or of departments of Government, and they do not then look to the general public for support or appreciation.

The work is intended to popularize its department, and in issuing it we have authorized and required a style of execution in regard to mechanical details not inferior to the best philosophical works, while its exterior form and mode of publication place it within the reach of the intelligent reader wherever books are sold.

The urgent wish of the Author to acknowledge the assistance of correspondents and observers induced the adoption of a lower price to such, as subscribers, than is warranted by the cost and value of the volume, and as this purpose has now been answered, the work is placed at its proper terms of Five dollars the copy.

J. B. LIPPINCOTT & CO.,
Publishers.

July, 1857.

AUTHOR'S PREFACE.

At the completion of the work for which the favor of the public has been to some extent solicited in advance, a word of apology from the Author is due to those who will receive it, in part for the delay in issuing it, and in part for the matter of the book itself. At two or three instances since the present design was in course of execution, the favor of Legislative bodies has been accorded to it to an extent which, if finally consummated, would have rendered it easy to expand the work to the full size required for the thorough treatment of every department, thus keeping the purpose to improve such aids to the utmost for the interest of subscribers, for some time in suspense. At the last this much desired aid failed from the usual contingencies attending such efforts alone, and not because the propriety of this form of assistance was not fully recognized.

By the liberality of the Publishers, however,—who at no time assisted or desired the solicitation of legislative aid—the ultimate execution of the work has been effected in the best possible manner, and much beyond the promise of the prospectus. The novel character of the engraving entitles that part of the execution to some indulgence, particularly on the point of uniformity of tone and coloring in the illustrations. The best artistic skill requires practice to perfect these modes, and to adapt them to the distinctive purpose; but a comparison of these charts with others that have been attempted in this purpose of climatological illustration will, it is believed, give them a rank fully equal to any not engraved in the most expensive manner on steel. The idea of this illustration is very difficult of perfect execution, and it can only be said that the difficulties intrinsic to the subject have been contended with, regardless of labor and time, by both author and artists.

These reasons are, perhaps, sufficient explanation of the delay in completing the volume, and no others need be referred to. But it may also be said that every moment of delay has been improved to consult recent works, and recent sources for statistical and other

matter. The various divisions have been in part re-written and condensed to admit this material as the printing proceeded; and though the selection and elimination for the limited space at command has been always difficult, and perhaps often unwisely done, it has at least always been laboriously and conscientiously attempted.

The researches which have resulted in the preparation of the present work on Climatology, have been prosecuted under circumstances requiring a word of explanation, particularly to those interested in Climatological Science as observers, a number unusually large in the United States, and deservedly standing as the real founders and supporters of this science in their private capacity, or as detached from institutions and government agencies.

From the date of the commencement of observations at the United States military posts in 1819, and at the New York Academies in 1824, observations by amateurs have been accumulated both by private and public agencies on forms generally similar, and previous to these efforts at uniformity, several accurate series were observed. From 1843 forward many records were transmitted monthly in such forms to Washington, to facilitate the dynamic or storm investigation prosecuted by Prof. Espy; and from 1848 they were sent in large numbers to the Smithsonian Institution, at its invitation, for the same purpose. At the close of 1851, a large collection had accumulated at the office of the Surgeon-General and the Smithsonian Institution at Washington, in the last case primarily for the purpose of discussion as detailed records in illustration of the dynamics of climate, and requiring to be discussed in manuscript form. Abstracts of the military observations down to 1842, were in course of publication, leaving the subsequent years, which were particularly valuable as reaching to the interior and Pacific districts for the first time, unemployed for any purpose of discussion.

At this time the author proposed to undertake a general discussion of the records from all sources in the sense of a CLIMATOLOGY—first undertaking to verify the records and eliminate their errors by grouping and comparison; and next to combine their expression for the purpose of using it as a valuable approximation to the various fixed quantities of climate, the average temperature, quantity of rain, the character and direction of storms, winds, &c. It was not then supposed that the records were adequate to precise determination of these conditions, but that the results would still have great practical value in Engineering, Agriculture, and Sanitary investigation, and that they would outline results in pure physics, as had been shown so successfully in other cases by Humboldt.

To facilitate this discussion, it was asked that all the records be referred to the Smithsonian Institution, and, though somewhat informally and irregularly, all the records of the official and State systems of observation were so referred, at one time or another, during the three years in which this purpose was prosecuted; and all were discussed in view of this general purpose of getting their best scientific and practical expression in a Climatology.

A large, and, as it now appears to the author, a disproportionate measure of time and attention was given to the dynamic discussion; a number of the principal winter or general storms of 1850, 1851, and 1852, were charted from simultaneous observations at from four to twelve periods each; the periods following each other so as to give successive panoramic views, as they may be termed, of the whole country at a definite hour. Thus one chart represented the condition at 9 A. M. of one morning, another at 3 P. M. of the same day, the variation of temperature from the mean being shown by lines passing through all points of like condition, as of 5° above or below the mean, &c. These lines arranged themselves about the centres of disturbance, both in excess and in deficiency. The pressure, or barometric observation, was represented in the same manner, by lines of equal variation from the mean—the mean taken as a point of comparison in all cases being that of the month in which the event occurred, and at the hour selected for the chart. The winds were represented by arrows, and the clouds and areas over which snow or rain was falling by different colors; the plan of illustration being much the same as that employed by Professor Loomis, in representing storms of 1836 and 1842.* These charts gave comprehensive views of the position and progress of these greater disturbances, at selected hours from the time they began, or were instituted, wherever that might be, until they were exhausted, or passed off the continent at sea; and fifty or more of these elaborate charts were completed. As the matter now appears, less value is attached to that discussion than was done at that time; the surface dynamics, particularly, are of very little importance, and an error easily derived from that system of charting is to attach to winds and other incidental phenomena, and to all the sensible phenomena of storms, indeed, an exaggerated importance.

Next to this the illustration of fixed or average conditions was undertaken, an illustration claimed to be possible against the general opinion, and in view of which great care had been taken to correct and verify the records of observation. These were first taken for

* Transactions of the American Philosophical Society.

single years, and Isothermal Lines were drawn for each month of 1850, 1851, and 1852; to which were added charts, showing the distribution of the quantity of rain for the same periods by shaded areas, graduated to show the relative quantities. Upon these were added Isothermal and Rain Charts for the mean of the same month for a series of years, with similar charts for the seasons and the year; and not only were the two or three years of detailed illustration combined in the concluding series, but they were constructed on the entire mass of observations, for all periods and from all sources. Thus an illustration at Charleston, S. C., would be based as much on the mean of ten years of observation from 1738 forward, as upon the last ten years observed there, ending with 1852; and so for every part of the country where reliable records could be employed for any date. The resulting average was designed to express the best possible approximation to an absolute mean, such as would be derived from accurate observations for the most extensive period.

The work referred to was prosecuted with excessive labor to near the close of 1854; a selection of dynamic charts was sent to the British Association at its meeting in 1852, and it was designed to present others at the meeting of the American Association for that year. This last failing to meet, the purpose was disappointed. In 1853 a series of papers in explanation of the leading points of the Isothermal and Hyetal or Rain illustration was presented at the Cleveland meeting of the American Association, and the volume of statistics and deductions, with the charts above referred to, was submitted to be printed as an appendix to the Report of the Board of Regents of the Smithsonian Institution, by the Senate. Changes in the policy under which the researches had been prosecuted, ultimately prevented the publication.

Subsequently, the author undertook the preparation of the accumulated statistics at the office of the Surgeon-General, for publication in a more extended form than had been previously designed, carefully correcting the entire mass in detail, and combining with the results of the last twelve years of observation, then unpublished, the summaries of all the observations preceding these, and upon these summaries, thus perfected, constructing Isothermal and Hyetal Charts for the mean of the seasons and the year. A Report discussing the principal features of the Distribution of Heat and of Rain in the United States was added, and the whole formed a large quarto volume, printed by authority of the War Department, and distributed early in 1856.

These references are deemed necessary to show that no part of the present work, whether supported by statistics and illustrations or not,

is the result of hasty or superficial discussion, and that all the steps of analytical investigation and detailed criticism required for such a purpose as that of constructing an approximate climatology, have been taken in advance. The author most regrets, indeed, the excessive labor given to this preliminary correction, as being, under the views now held, of little importance if a correct tone of inductive generalization is employed. The opinion which assigns less value than before to the dynamic, or storm discussion, as a feature of surface dynamics, is the result of the most extensive and laborious investigation under a higher sense of its importance than that now entertained, and is itself a deduction from the elaborate charts then constructed. Something similar may be said of the Isothermal and Rain Charts for single months and years; they are far subordinate in value to those for the months derived from extensive series of years, and these last are also subordinate to the summaries for the seasons, embracing the mean of three months. The Isothermals and Rain Charts for the fixed mean of each month are of great value, however, and the great expense of their illustration has alone prevented their introduction in the present volume.

The practical features of American Climatology have been foremost with the author, through the entire discussion, in part for the reason that a research, in this new department of physics, must commend itself to economical interests or fail to be sustained. Direct as its relations are to so many practical and business interests; and permitting advances in pure physics unequalled in any other department, this practical difficulty has been heavily adverse to it. The chapters of this work are, in their titles, significant of the general purpose entertained in the entire design and execution.

The author's indebtedness to many gentlemen for material of observation, and for encouragement in the difficult work of perfecting the general discussion of the materials of our Climatology, is peculiarly heavy, and it would be impossible to pass over these obligations without especial acknowledgment here. It is obvious that not only the statistics, simply, are difficult of accumulation, but the wide comparison and discussion required, demand unusual facilities for access to official records, and to scientific and other libraries. Most important isolated facts and results, also, obtained by gentlemen at distant points distributed over the country, have been almost constantly furnished in correspondence and in detached publications, and though these may not appear in the statistics or references, they have had a measure of value which the writer would acknowledge in grateful terms.

In regard to these and other sources of assistance, without desir-

ing to impose on any of these gentlemen the least responsibility for the use ultimately made of the privileges they accorded, or to assume for them any endorsement of the completed work, the author most gratefully recognizes his duty in the imperfect acknowledgment here made, and he only begs that the omission to name others here may be set down to the wish not to obtrude a large list.

By those who may at any time have prosecuted researches in departments of science imperfectly defined, where efforts at advancement are like reaching forward in the dark, and often loaded with oppressive doubts, it will be readily understood with what gratitude the author names first a Letter of strong approval from the illustrious Baron Humboldt,—whose models were his guide, and whose tone of generalization his highest ambition to attain,—recently received on sending a copy of the report and charts prepared under authority of the War Department in 1856.

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Hon. Chas. Mason, Commissioner of Patents, Washington.
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Washington, June, 1857.

CONTENTS.

IMPORTANT LISTS AND TABLES.

PRELIMINARY CHAPTER.

The design of the present work appears to require an illustrative or explanatory chapter, in consequenee of the peculiar position Climatological Science holds, or has held, in regard to what is termed *positive science.* It has always been difficult to reconcile this with other departments in which observations in numerical form, either instrumental or otherwise, are used as the basis of all deduction, because observations of temperature and of other climatological conditions are not the equivalent of observations elsewhere, as in astronomical science. They differ essentially in value as matters of detail, and while the last are positive data singly, a great aceumulation is required in climatology, and extensive series must be concentrated in the form of perfected mean results, in order to settle anything. It is yet a matter of doubt whether these accumulations, in their best form, afford any reliable basis for prediction.

Great disappointment was felt when the first instrumental observations, of the barometer and thermometer, were found to give rude approximations only, which varied so widely and so inexplicably among themselves that no formula could be applied to obtain their corrected expression, and to illustrate the precise physical changes. This diffieulty has never been surmounted, and from the intrinsic character of atmospheric phenomena never can be, so far as simple phenomena are concerned. It is necessary to accumulate recorded facts, and to derive averages from extended periods of time, to fix and define the climatological conditions which may be considered constant; and for the extremes and oscillations, constantly presented as facts of great interest at the time, a similar consideration as averages is the best that can be done with them. The measures of heat, moisture, rain, and atmospheric weight, are all to be treated alike in this respect; the averages afford fixed quantities which must first be defined, and from these the distance to which the extremes go—the average, and the extreme measures of this distanee—may be calculated numerically as a part of the discussion.

Perhaps in consequence of the peculiar difficulty of the ease, and of the apparent instability of all these elements, this subject has been

enveloped in absurd and grotesque speculations in all ages, and it is still half buried under them. While astronomical knowledge derived from observation was accurate almost from the outset, and the Chaldean observer gave positions recognized as accurate after an interval of thousands of years, the physics of the atmosphere were apparently selected for the purpose of caricature, and all its phenomena were treated with singular and often ludicrous exaggeration—personified, and burlesqued, as we ought to suppose, since it is hard to say that the early writers, who were sensible on all other subjects, did not know how grossly inaccurate their treatment of climatological facts really was. They at least leave us in doubt whether they were in jest or in earnest, and they sometimes appear conscious that they are caricaturing the matter, and playing with it for their own amusement.

Theophrastus and Aristotle wrote freely on the subject; the first, a *Treatise on the Signs of Rain*, which is noticed in the *Philosophical Transactions* by Horseley,* who "reluctantly ranks it with Pliny's

* In the earlier Nos. of the *Philosophical Transactions* the papers of Dr. Beal and Dr. Wallis, 1664 to 1675, first take up the application of the Torricellian experiment and the construction of the barometer to climatological purposes, or to the comparison of atmospheric weight, temperature, &c., at different places. Dr. Beal accredits Mr. Boyle with the first application of the barometer to the measurement of minute atmospheric changes (*Phil. Trans.*, No. 9, p. 153), and expresses himself so well pleased with the discovery that he looks upon it as "one of the most extraordinary inventions of the world." Hon. Robert Boyle, Dr. Halley, Mr. Townley, of Lancashire, Dr. Plot, of Oxford, and others, engaged in these investigations.

Dr. Plot and Dr. Lister (*Phil. Trans.*, No. 169, p. 350) perfected the mode of reading the barometer at Oxford, in 1684, kept a record there, and expressed some sanguine anticipations in regard to "predicting the weather," as they say had been done by "the learned Dr. Goad, of London," from reference to instrumental diaries. They refer to "the industrious Walter Merle, Fellow of Merton College, who thus observed the weather here at Oxford every day of the month, for seven years together, viz: from Jan. 1337, to Jan. 1344; the MS. copy of which is yet remaining in the Bodleian Library." Subsequently Dr. James Jurin, in 1723, invited an association in forming meteorological diaries, and gave a form, which was quite generally followed. Mr. Will. Derham was an early and able collector; he, with Dr. Halley, contributed papers and collections to the Royal Society through a long series of years, particularly bearing on this research in the sense of a Climatology.

The following is the form, with a sample of entry, proposed by Dr. Jurin, after which the register of Dr. Lining at Charleston, S. C., and others in the United States were kept:—

DIARÏI FORMA.

DIES ET HORA.	BAR. ALT.	THERM. ALT.	VENT.	TEMPESTAS.	PLUVIA.
Nov. St. V. 1; 8 a. m.	29.75	gr. dec. 49 6	S. W. 1	Coelum nubibus obduct.	0.035

This appears in the *Philosophical Transactions* for 1723 (No. 379, p. 422); and in a

absurdities," and who expresses great respect for the ability of the writer on other subjects. Pliny wrote profusely in illustration of this inexhaustible subject of interest, and his storehouse of reasons for one fact or another furnishes foils of every form to parry the errors of speculation now. Kircher, in the 17th century, rehearsed most of these absurdities with a good deal of amplification and illustration, and with a tone of gravity and credulity which proved his sincerity, at least. They only began to be cleared up with the best scientific men at the rise of the Royal Philosophical Society of London, and at the time of the invention of the barometer and thermometer, with the comparison of observations which soon after ensued. In this period, or from 1680 to 1770, many able writers appeared in the *Transactions*, and they are full of evidence that climatological laws were then vigorously and sensibly sought, and by correct processes, so far as experiment and observation could go.

The greatest activity in this department, perhaps, existed near the close of the 17th century, and in connection with the invention of the barometer and thermometer, and the production of the first observations of these instruments. The spirit thermometer was in use long before the mercurial thermometer, and, somewhat singularly, mercury was used in the barometer a quarter of a century before it was applied to the construction of the thermometer. The mercurial thermometer came last, and it scarcely supplanted the spirit thermometer in England in half a century after its invention, which was about 1720—Hawksbee's spirit thermometer was only supplanted in England by Six's thermometer (partly mercurial and partly of spirit), in 1782.

From 1720 to 1744, frequent attempts were made to ascertain the laws of atmospheric weight and temperature, and of the changes of these, by collecting and comparing barometric observations, but the imperfection of instruments defeated the purpose. Great confidence was felt that weather changes of the greater sort, as those of unusually wet, cold, or dry seasons, could be anticipated by a knowledge of instrumental observations, according to the analogies of other positive measurements in physical science. It was supposed that such observations would give the key to the otherwise mysterious phenomena, and that these instruments would disclose direct and uniform relations, as well defined as the movements of the stars. The subsequent discovery that the observations gave no direct key, and that they must be accumulated over a wide area and for a long period of time, tended

subsequent number, "Mr. Isaac Greenwood, Professor of Mathematics at Cambridge, New England," gives a form for marine observations, and recommends taking them regularly.

very much to chill and discourage the investigation, and it fell again into the position of a record mainly for the interest its startling phenomena gave, is a sort of interest it will never fail to have, and in which, though having a philosophical air, there can be no progress as positive science.

There were instances of rigid and logical investigation, however, even at this earlier time, one of which was a paper in the *Transactions* for 1775, by Samuel Horseley, LL. D., Secretary of the Royal Society, discussing the observations then taken for one year, by order of the society. He quotes the views of many Greek and Latin writers, particularly Theophrastus, Aratus, and Pliny, and his conclusions in regard to the moon's influence are worth transcribing. "On the whole I do not deny that the observant husbandman will find a variety of useful prognostics in the appearance of the moon and the heavenly bodies in general, but they will be prognostics of no other kind and for no other reason than the spattering of the oil in the industrious maiden's lamp, or the excrescences which gather round the wick." That is, they were merely in the atmosphere through which we saw the bodies. Pliny's eight critical days of the moon's age, the 3d, 7th, 11th, 16th, 19th, 23d, and 27th, he also notices, as similar to all the fictions of this sort.

A consciousness that the field observed was too narrow, though possibly not itself clearly understood, evidently assisted to discourage the pursuit of climatological science. The *Philosophical Transactions* are without an important essay on the subject for a long period after 1775; and much that appeared from 1820 to 1840, is confined to the disproof of popular fallacies; the *Transactions* having, for this last period, fallen behind the new lines of generalization initiated by Humboldt, and the great advances he made. Under Humboldt's efforts and auspices, with those of Sir William Herschel, points of observation were multiplied and extended, and generalization was first successfully applied in the form now found necessary; but progress in public appreciation was still slow, circumstances were unfavorable to the diffusion of results, and the brilliant generalizations at the basis of the construction of Isothermal Lines alone succeeded in establishing this branch of physics on its own rightful and peculiar footing. Recently the reconstruction of Humboldt's original models by Dove, with the indefatigable labors of the latter, in accumulating observations from widely separated sources, and in constructing upon them generalizations not limited to one continent or one hemisphere, but truly of a cosmical character, have added rapid steps of advancement.

Yet the excrescences of so many centuries of growth still greatly encumber the whole science, and particularly the appreciation it has in

public opinion of the more intelligent sort. The moon still has an important agency assigned to it, in moulding the incidents of climatology, at least, and this view is by no means confined to what is technically called popular belief. Many of these points of asserted influence have been examined by the aid of the most rigid analysis of long periods of observation, with the result of rejecting the whole agency in every case. The Herschels repel the charge or assertion that either of them advocated the existence of any system of lunar influences, and they particularly repudiate the weather table, often attributed to them.*

It is interesting to notice that so important an observation as that of the quantity of water falling in rain, had its origin in bold doubts of a prevalent belief that fountains and rivers were supplied from internal masses of water—arteries and veins of the sea, circulating the life blood of the earth. A French author, Denys Papin, printed a work on the *Origin of Fountains*, at Paris, in 1674, the object of which was to show that the rain and snow-waters are sufficient to make the fountains and rivers run perpetually.

"In order to give a gross estimate of the quantity of water running away in rivers and springs, it will be first necessary *to agree in the way of measuring these two sorts of water*. . . . For the measure of rain and snow-water, I have found that from October, 1668, to October, 1669, there had fallen so much of it as amounted to the height of eighteen inches seven lines; and from this same month of 1670, to the same month of 1671, there had fallen so much as came to the height of eight and a half inches; and from January, 1673, to January, 1674, to the height of twenty-seven and a half inches; of which, taking the mean, we have nineteen inches two and a third lines."

The author goes on to inquire whether this quantity could "make a river for the whole year," in controverting the received opinion that the rivers got at least a part of their water from the interior of the earth. He concludes that the rain-water is sufficient;—

"so that there needs but the sixth part of the rain and snow-water that falls in a year, to run continuously through the whole year."†

Howard, in the preface to his work on the Climate of London, first prepared in 1818, states with great force the condition of climatological

* Letter of the younger Herschel (cited in Report of Regents of New York University, 1855).

† The editors of the Philosophical Transactions of the Royal Society, in which this extract is given (*Phil. Trans.*, No. 119, p. 447), give a commentary on this proposed measurement of the quantity of water falling in rain. "The like to which has been attempted here, and proposed to the Royal Society some years since by Sir Christopher Wren, who, by the contrivance of a rain-bucket, had taken account of all the water that fell for a considerable time." The popular belief in the internal origin of fountains remained for a long period subsequent to this date, however.

science at that time, and the lapse of nearly forty years finds the condition to require a statement in some respects similar:—

"Meteorology, though greatly advanced of late years, especially in what regards the perfection of instruments, and in the art of observing the changes of the atmosphere, is yet far from having assumed the regular and consistent form of a science. Its facts lie, for the most part, scattered—or rather buried—in volumes chiefly taken up with other and more cultivated branches of natural philosophy, and it is only when detached publications have been ventured on by individuals engaged in the study of particular classes of phenomena, that its principles have been developed with the clearness and method of which they are susceptible. *A pretty large number of observers have been long engaged in doing for this science what the Chaldean shepherds are thought to have done for astronomy.* We may now probably venture to anticipate some of the conclusions which posterity will otherwise have to draw from our data." . . . "Should it be inquired for what end, the answer, without travelling to more remote consequences, may be, that it is for the benefit of agriculture and navigation, two objects of the utmost magnitude."

A thorough treatise on the views held during historic and recent times, popularly and by the scientific, would be of great use as well as of great interest; showing, as it would, the natural modes of dealing with phenomena constantly recurring, and always of a striking and interesting character, the solution of which was impossible with the most learned. The point of *causation* is at once the most ready to recur, and the most difficult of solution;—*why* are the extreme variations of heat, moisture, and other sensible conditions, irregular and impossible to foretell as they are, and what are the *causes* of them? As we have no satisfactory answer yet, it is too early to characterize the opinions which charged these to gods, to caves in the earth, to distinct personified agencies, and to the stars or the moon, as wholly unsound and unnecessary. The wonder age lingers yet, indeed, and it may refresh our view of its absurdity to refer to the time when the phenomena were localized, making the solution easier, if it were only correct. Pliny says that—

"In many houses there be hollow places devised and made by man's hand, for receipt of wind, which, being inclosed with shade and darkness, gather their blasts."

He also gravely asserts that—

"There be certain caves and holes in the earth which breed wind continually without end, like as that one is in Dalmatia with a wide mouth gaping, and into which, if you cast any matter of light weight, there ariseth presently a stormy tempest, ... whereby we may see how all winds have one cause or another"!

There are still many views and theories attributing to the winds almost intelligent agencies, and assigning to them the causation of many facts and results, as though they were at least independent agents, instead of being simply volumes of "air in motion."

It is not surprising that those accustomed to mathematical processes and positive results regard climatological physics as almost beyond

the pale of positive science. It is so easily overloaded with theories, and so readily shaped to conform to any theory by a little selection among observations, that the work of disproof of these would itself absorb all time, if it were guarded as rigidly as other sciences are. The startling phenomena, and the air of pyrotechnic display so easily made to cover the public appreciation, are the chief hindrances to its prosecution. There is great need of the occupation of a middle ground between mathematical precision and theoretical looseness, seizing the salient points with a clear sense of the proper distinctions, and lastly, what is of still greater importance, putting them to a common sense and intelligible use.

The actual position of the science of climatology, as a department of physics, and the relative value of the carefully detailed and accurate observations made in this and in astronomy, are very clearly stated in the last annual report of the British Astronomer Royal, who regrets that, while the Greenwich astronomical observations have assumed such a shape, that the astronomer will find all the moving bodies of the solar system presented with the utmost accuracy, the same assurance cannot be applied to meteorological observations; not, however, from any defect of instruments or observations, for these have acquired an extraordinary excellence and precision, particularly in photographic registry.

"But after having obtained the immediate results of observation, with the utmost completeness and exactness, we are absolutely estopped from making further progress by the utter absence of even empirical theory."

The defects of the research so clearly stated here, are believed to be inherent to the subject, in a great degree, and to arise from the fact that positive formulas cannot be applied to these detailed observations, however accurate. Generalization, alone, can seize their true expression, and this generalization must be derived from masses and summaries, by rigid deduction and comparison.

The first of European climatologists, Dove, now insists upon the defectiveness of the deductions, which it was, until quite recently, the custom to draw, based on the assumption that the known European climates were the standards, the normal or natural climates for their latitudes—treating all differences from these as anomalies. It is now known that these assumed standards are largely anomalous themselves, and that wider views alone can lead to correct deductions even there.*

It may seem an unnecessary expansion of the field, to treat of the

* See Dove's papers in the Transactions of the Berlin Academy, and in Proc. of British Association; and particularly a paper on Variations of Atmospheric Pressure, in Edinburgh New Phil. Magazine, for July, 1853.

climate of Asia in connection with that of the United States; but, in point of fact, it is that which is most necessary to be done, and most pertinent to the illustration of merely local peculiarities here.

There are few works adapted to the present requirement, either as applied to localities, or to the temperate climates generally. The most that has been written is in the form of incidental treatises, attached to some other, or general work. Sir John Richardson has associated an admirable review of the climatology of British America with his history of an Arctic Expedition in search of Sir John Franklin, which is the most valuable existing notice of that part of the continent, and quite indispensable in the examination of the adjacent districts of the United States. The direct association of scientific observations with a practical climatology, is the most valuable feature of this, as of any similar work. The observatory established by the British Government at Toronto, has furnished a very valuable series of observations, from which the constants of temperature, humidity, &c., have been deduced, and some memoirs of a general character have been based on this series by Col. Sabine, Capt. Lefroy, and Prof. Cherriman. There are other notices of a more limited or incidental character, which, with the above, give a very good knowledge of the climate of British America.

For the United States, the work of Dr. Forry is perhaps the most complete, though but an outline of the generalizations for which observations are now accumulated. No observations had then (1842) been made west of the Mississippi Valley, and, indeed, those actually used by Dr. Forry, were only brought down to 1831. Since that time, we have, heretofore, not only the addition of twenty-four years of observation, but of the immense area of the western half of the continent, which is now quite completely embraced by the records at the military posts, and which has had, in addition, a thorough examination by surveys and amateur observers.

It is impossible yet to make a treatise on American Climatology, as rich in research as one might be made for Europe. Admiral Smyth* has shown that historical absurdities and extravagances may be so sifted as to identify the truth of them with existing phenomena. His work is most suggestive of the fulness of interest which attaches to popular opinions, in any age, and to those singular blendings of sagacity and charlatanism which have been always busy in prediction and prognostication in regard to the weather. Our history is full enough of these peculiarities, but sufficient time has not elapsed to

* The Mediterranean, A Memoir, Physical, Historical, and Nautical. By Rear-Admiral Wm. Henry Smyth. London, 1854.

permit us to sift them, and to decide what the germs of truth in them are, if they have any. In Europe, two thousand years and more of historical comparisons may develop important results, particularly in regard to the permanence of special features; and the identification of particular winds or descriptions of storms, after so great a lapse of time, is an admirable test of the popular measure of accuracy in description. If such an illustration of our own climate were possible, it would be found to dissipate the apprehensions so frequently entertained, that it is becoming more variable or extreme, and to break the force of the remark that some extreme now experienced is wholly unprecedented.

It will be the design to adhere to the most rigid deduction in what is here said in regard to determinations in climatology, and to make the work distinctively one which may be designated by the title of positive climatology. In the admirable volumes of observations published by the Russian government, giving the results at the Magnetical and Meteorological Observatories of that immense empire, series of temperature and other records are constantly published, as observed by some scientific gentleman or local institution for a period of years, and entitled *Materials for the Climatology of Russia.* The value and importance of these materials are fully recognized, though no effort to construct a climatology upon them has yet been made. Similar materials exist here, and are at least equally abundant and accurate. With the results of the officially supported systems of observation, at the Military Posts, and at the New York Academies, a body of materials for the Climatology of the United States exists of the very best and most complete character, considering the brief period since the occupation of some parts of the territory. The chief difficulty is in properly selecting from this collection of materials, and in using the immense mass, from the mere labor involved, in demonstrating the accuracy of the results. The statistics need to be given a somewhat disproportionate place also, because of the incredulity with which conclusions are received, and this fact compels the publication of much that may subsequently be omitted.

Without losing sight of positive determinations of every sort, it will be attempted to interweave these with the practical matter so much demanded, and whatever measure of success may attend the effort, it will only fail because the work itself is not properly done, not because the materials are deficient, or because the needs and capacities of the subject do not fully require and justify the attempt. In an address before the Imperial Academy, at St. Petersburg, in 1828, Humboldt stated, with great force, the advantages which would sooner or later

result from the extension of observations in the immense areas of Russia and North America.

"A country which extends over more than 135° of longitude, and from the happy zone of the olive to the climate where the soil is only covered with lichens, may advance more than any other the study of the atmosphere, the knowledge of mean annual temperatures, and, what is more important for vegetation, that of the distribution of the annual heat over the seasons. Add to this the hygrometric state of the air, and the annual quantity of rain, so important to the purposes of agriculture. When the varied inflections of the isothermal lines shall be traced from accurate observations continued for at least five years in European Russia and Siberia, when they shall be prolonged to the western coasts of North America, where that excellent navigator will soon reside,* the science of the Distribution of Heat on the surface of the globe, and in accessible strata, will rest on solid foundations."

And in regard to the United States, he remarked in continuation:—

"The government of the United States of North America, deeply interested in the progress of population and the varied culture of useful plants, has felt for a long time the advantages presented by the extent of its territory from the Atlantic to the Rocky Mountains, and from Louisiana and Florida to the lakes of Canada. . . . . . I have already mentioned in a memoir, where I have discussed the causes on which the differences of climate in the same latitude depend, upon what a great scale this fine example of the United States may be followed in Russia."†

Of the results thus early indicated as likely to accrue from the two systems of observation, it must now be said that they have practically been realized as far as the accumulation of observations may go. The Russian observatories have encircled the earth in the higher temperate latitudes, and their published results are an imperishable monument to the honor of that government. Those of the United States Military Posts have extended greatly beyond the limit above indicated by Humboldt, and, though differing from his models perhaps in regard to scientific accuracy of observation and discussion, they are adequate to the solution of the great questions named by the Master of Physical Science.

Upon the basis of positive results above elucidated, it is intended to add as much as the space will permit of what may be, to some extent, in the tone of a report upon the value of the temperate latitudes of this continent, from the point of climatological adaptation to occupation by populous states. Such results have been, from the outset, the mainspring of the Author's efforts to develop the science, and no opportunity so much requiring such discussion and comparison as

* In allusion to the establishment of an Observatory at Sitka, Russian America, under the direction of Wrangel.

† Edinburgh Journal of Science, 1829.

the present, has occurred at any recent time, or one where interests so large were to be affected. In the United States and British America, the migratory masses have now reached the limit of known climates, and are ready to advance over the immense areas of the interior and the west. The climate of these is the first question, since most other conditions essential to occupation are the incident of this, or rather, are defined when this is defined. In equable and moderate climates the soil is always cultivable, and in desert climates rarely so. Mountains and surface configurations of course affect the case, but it is hardly possible that mild and favorable conditions should be largely neutralized by configuration alone.

This application of the results of the discussion to the industrial and commercial development of the unoccupied portions of the temperate latitudes here deserves even more space than can now be given it. To draw a parallel of conditions in the old world, we must go back to the earlier historic ages when the Mediterranean was the seat of civilization, and when the Greek and Roman colonists began to expand over the west and north—the gates of the Mediterranean corresponding, in no small degree, to San Francisco; and the Gallic and Scandinavian plains, with the islands of the savage Britons, to the vast areas at the Northwest here. Over all these areas we may now reach with scientific precision, defining the climate and capacity for occupation, and permitting the advance of states in a steady and certain progress, until every part of the new world shall attain equal development with the old.

The central idea of the comparative climatology of the temperate latitudes of the two continents, is that of *correspondence in like latitudes and like geographical positions.* This implies a symmetry of arrangement in the climates, if it may so be called, which greatly assists in determining what the conditions are, and still more assists the practical business of putting them to use. Thus Vancouver Island is analogous in position to the British Islands—in like latitudes and on the same side of the continent—and from observations near it, we find the cool summer, the warm winter, and general humidity of the British Islands. To these facts little of positive observation need be added to warrant the general inference that the cultivation and productive capacity of England may be reproduced on the Pacific here, and all the vast systems of industrial, commercial, and social results which follow in the train of such conditions.

For other districts, and particularly for the interior at latitudes from 47° to 58° north, the like analogies with Europe may be deduced. Russia, the north of Germany, the Black Sea and Baltic districts, have equivalents of general climate and geographical position, carrying

with them equivalent capacities for cultivation and the organization of states. Most of these areas are now unoccupied, and the most effective cause of the present absence of effort to colonize them is to be found in the errors existing in regard to climate. It is thought that all parts of this continent are formidable from their severe climate at such latitudes as we know the Canadas and Labrador to be formidable, while in truth, these districts afford no guide whatever to the climate of the interior and west coasts. Deriving our ideas from like geographical positions in Europe, we may see that at the west ten degrees of latitude does not more than express the amelioration of those areas over the areas at the east. The winter of Norfolk is transferred to Puget's Sound, that of Washington nearly to Sitka, latitude 57°, the highest observed point of the Pacific coast—the one ten degrees, the other eighteen degrees of latitude of difference.

The plains of the Missouri, Saskatchawan, Athabasca, and Mackenzie Rivers, afford contrasts with the land areas at the east nearly as great, and in the train of each of these general facts, the most important industrial and commercial results must follow. It is the application of these which is, not less than the positive results in physical science, the purpose and spirit of the present work, and it may not be too much to ask for this effort to give precision to the knowledge of vast areas over which our advancing states are soon to go, a measure of indulgence and attention, it would not deserve as the mere discussion and definition of physical conditions which were already fully known practically, and fully developed in their relations to the occupation of the country.

The compression of matter rendered necessary in every part of the volume, prevents the desirable fulness of reference in all the divisions of the subject, and particularly limits the notices of the capacity of the northwestern areas too much—now the least known, and yet the most valuable that remain unoccupied on this continent. It has not been thought desirable to compress other portions more than has been done to permit this elaboration, and it must be left to a subsequent opportunity, if such should occur. The whole work undertaken, it has been often and painfully felt, embraces too wide a range to be satisfactorily treated. Each of its departments requires a volume rather than a chapter, and an extent of research such as the author cannot claim to have made; and for all taken together, such as it is scarcely possible for one person to make. But it would be impossible to omit any one of these divisions from a Climatology, and any work of the sort that may now be constructed must necessarily be but an approximation to completeness, or rather but an opening of many parts of the subject.

I. SUMMARY OF THE STATISTICS OF METEOROLOGICAL OBSERVATION.

THE required statistics in regard to temperature, quantity of rain, and other conditions of climate have heretofore been wanting on any general scale, or such as is necessary to make the comparisons which render the subject intelligible. Single or scattered results and tables are not readily understood, because the data for comparison are wanting, but when the measures of heat and of the quantity of water falling in rain, or of any other features of climate, may be compared for many points over the whole area of the United States, and for a succession of years also, it is easy to get at their meaning and value.

The statistics of greatest value in a general climatology, are the monthly summaries of these measurements, giving the averages, or the fixed quantities, with a degree of accuracy proportioned to the extent of the periods of observation. As all other conditions of climate are subordinate to these, the summary of observations of the wind and weather may be compressed into a small amount for any general purpose, and it is only necessary to give them in full when a special illustration of the particular branch of the subject to which they belong is undertaken. The barometric observations belong to a specific department of physics, and they may be discussed separately for many results.

In constructing the following summary tables, a sufficient number of representative stations has been introduced, at which correct observations of temperature and of the quantity of rain have been made in the United States, with a selection of similar summaries at stations in Europe and Asia, where the positions and periods best represent desirable points of comparison. For the United States, east of the 100th meridian, the number of stations is sufficient, and the periods embraced by the observations are quite adequate for any practical purpose, and the results illustrated are very near to accuracy. The comparison which may be made with the best known European and Asiatic districts, by the use of the stations cited as their representa-

tives, becomes also as clear as is necessary for the construction of a climatology. It has been designed to so arrange all these, that they give the fullest expression to the deductions by mere inspection of the statistics, and their arrangement in geographical order, and in their natural relations as nearly as may be done, accomplishes this very clearly for the greater part of the United States. The correspondence, and the contrasts also, which would be supposed to belong to these positions, is seen to belong to the summaries in a remarkably distinct form, and it can hardly be mistaken what their expression is, and whether the deductions given in the charts and explanation truly express it.

The first class of tables is made up of the temperature summaries, condensed in means for each month, season, and the year, with notes of the position of the station, the conditions and hours of observation, and of the authority. The positions are very carefully given, and the altitudes, particularly, are regarded as an indispensable item of position. To the stations in the temperate latitudes on this continent, there is added a full representation of all observed European and Asiatic districts. These have been mainly taken from the very great mass of detailed and summary tables constructed by Prof. Dove, and published by the Berlin Academy in its quarto volumes of Transactions for the years 1838, 1839, 1845, 1846, and 1852. The magnitude of this collection cannot fail to impress any one who examines it with the conviction that the statistical elements of Climatology are already most ample, and that this immense mass must be adequate to fully establish the results and conclusions to which the statistics point. It is to be regretted, that in the reprints of the summary tables, the original authority has not been given in all cases, with the dates of the several periods. These facts are difficult if not impossible of access in American libraries, but the original sources have been consulted as far as may be done, and all the notes have been retained, by which their accuracy may be judged.

The period of observation and calculation of mean temperatures is much greater in the United States than has been supposed, two or three series commencing nearly at the date of the invention of the mercurial thermometer, and before that form came in general use. The earliest series at Cambridge by Dr. Winthrop, was taken with Hawksbee's spirit thermometers;* and others in New England were taken with Six's thermometer as late as 1810. This was a register

* In this thermometer, "the point of extreme heat is marked 5° above zero, and so is graduated down to 45°, which is the point of temperate; and down to 65°, which is the point of freezing."—*Phil. Trans., Martyn's Abridg't*, 1732 to 1744, p. 560.

thermometer constructed of spirit instead of mercury; Dr. Lining used Fahrenheit's thermometer, just then come in use, at Charleston in 1738, and the correction of other records to the scale of Fahrenheit was generally made on publication. From 1738 to the present time the continuity of the record may be maintained either at Charleston, Cambridge, or Philadelphia; the record at Cambridge having but a few years omitted since 1742.

The number of carefully observed stations in the United States is also great. In addition to those incorporated in the tables giving monthly averages, and to those which space has rendered it necessary here to compress into the smaller form of the table giving averages for the seasons and year only, there is a large list which could be clearly given only in a full detail for the years and parts of years observed, because of irregularities and interruptions. These, with many others yet unpublished, have been discussed and consulted by the author in the construction of the isothermal illustrations first presented to the American Association for the Advancement of Science in 1853, for that embraced in the *Army Meteorological Register and Report of* 1855, and for the present work. The following summary gives the number of series consulted, with the aggregate of years of observation, and the names of stations at which valuable results have been computed, not given in the tables:—

MAINE, whole number of stations, *twenty:* aggregate, 193 years. Bangor; Steuben, 3 years; Brunswick, Bowdoin College; Gardiner, 16 years; Fryeburg, 2 years; Perry, Washington County, 3 years; Oldtown, 3 years; Windham.

NEW HAMPSHIRE, *ten* stations: aggregate, 63 years. Londonderry, 3 years; Dublin, 2 years; Salmon Falls, 2 years.

VERMONT, *twelve* stations: aggregate, 79 years. St. Johnsbury, 3 years; Montpelier; Windham; Craftsbury; Middlebury; Rouse's Point.

MASSACHUSETTS, *thirty-four* stations: aggregate, 472 years. Richmond; Newburyport; Pittsfield; Southwick; Wood's Hole; Taunton.

RHODE ISLAND, *five* stations: aggregate, 50 years.

CONNECTICUT, *fourteen* stations: aggregate 68 years. Middletown University, 4 years; New Haven; Saybrook; Salisbury, 3 years; New London, 4 years.

NEW YORK, *one hundred and two* stations: aggregate, 1025 years. New York City, W. C. Redfield, 2 years; Liberty, Sull. County, 3 years; Sing Sing, 2 years; New York City, Bloomingdale Asylum, 1 year; Greenville, 2 years; Somerville, 3 years; New York City Hospital, 2 years; Adirondack, 1 year; Geneva, 2 years; Brooklyn; Smithville, 2 years; Fort Porter, 2 years; Oyster Bay, L. I., 3 years; Amenia, 1 year; Palmyra, 2 years; Fort Wood, 2 years; Chatham's, Col. County, 3 years; Jamestown, 3 years; Sag Harbor, 3 years; Seneca Falls, 2 years; Ovid; Beverly, 3 years; Nichols, Tioga County, 1 year; Angelica, 2 years; Madrid, 4 years; Buffalo, Prof. Hunt, 2 years; Spencertown Ac.; White Plains, 2 years; Watertown, 2 years.

NEW JERSEY, *six* stations: aggregate, 53 years.

PENNSYLVANIA, *fifty-eight* stations: aggregate, 275 years. Alleghany; Westchester; Sugar Grove, 3 years; Morrisville, 10 years; Beaver; York; Randolph, 3 years; Haverford, 3 years; Easton; West Greenfield; Moss Grove, 3 years; Pocopson; Erie; Newtown; Hollidaysburg, 3 years; Nazareth; Pottsville; Lewistown; Ceres, 2 years; Pittsburg; Philadelphia; Reading; Darby, 3 years.

DELAWARE AND MARYLAND, *ten* stations: aggregate, 85 years. Newark, Del., 3 years; Baltimore, Prof. Steiner, 2 years.

DISTRICT OF COLUMBIA, *five* stations: aggregate, 25 years.

VIRGINIA, *sixteen* stations: aggregate, 93 years. Buffalo, 2 years; Charlestown; Richmond, 4 years; Brunswick Co., 3 years; Winchester, 7 years; Charlottesville; Portsmouth, 3 years; Huntersville; Louisa Co., 1823–1828.

NORTH CAROLINA, *six* stations: aggregate, 44 years. Lake Scuppernong, 2 years.

SOUTH CAROLINA, *twelve* stations: aggregate, 67 years. Waccamaw, 2 years; Med. Soc. Charleston; Abbeville; Aiken.

GEORGIA, *ten* stations: aggregate, 75 years; Milledgeville, 1819; Augusta; Fort Henderson.

FLORIDA, *thirty-one* stations: aggregate, 149 years. Fort Heileman; Picolata; Indian Key, 2 years; Fort Wheelock, $\frac{3}{4}$ year; Fernandina, 1820; Fort Harlee, $\frac{1}{4}$ year; Fort Holmes, $\frac{1}{2}$ year; Fort Russell, $1\frac{1}{2}$ years; Fort Wacahotee, $1\frac{1}{4}$ years; Tallahassee; Jacksonville, 7 years; Pensacola, Navy Yard, 8 years.

ALABAMA, *seven* stations: aggregate, 30 years. Eutaw; Monroeville; Tuscaloosa.

MISSISSIPPI, *eight* stations: aggregate, 48 years. Port Gibson; East Pascagoula; Garlandsville; Pass Christian.

LOUISIANA, *fourteen* stations: aggregate, 125 years.

TEXAS, *twenty-five* stations: aggregate, 88 years. Gonzales, 3 years; Dallas, 3 years; Matamoras, 7 years (Dr. Berlandier).

INDIAN TERRITORY, *five* stations: aggregate, 68 years. Doaksville, 3 years.

ARKANSAS, *four* stations: aggregate, 15 years. Washington County.

MISSOURI, *six* stations: aggregate, 65 years. Hannibal, 3 years; St. Genevieve.

KANSAS, *four* stations: aggregate, 40 years.

TENNESSEE, *seven* stations: aggregate, 25 years. Dixon's Spring, 3 years; Fayetteville, 2 years.

KENTUCKY, *eight* stations: aggregate, 33 years. Danville; Millersburg; Bowling Green; Prospect Hill; Ballardsville; Maysville.

OHIO, *twenty-five* stations: aggregate, 178 years. Dayton; Mount Vernon, 3 years; Granville; Cincinnati, J. Lea, 18 years; Zanesville; Columbus; College Hill, 2 years; Savannah; Marietta; Jackson, 10 years; Gallipolis; Keene.

MICHIGAN, *fifteen* stations: aggregate, 123 years. Monroe; Ontonagon; Kalamazoo; Saginaw; Detroit; St. James; Coldwater; Brooklyn.

WISCONSIN, *eighteen* stations: aggregate, 106 years. Platteville, 3 years; Madison, 3 years; Bellefontaine, 3 years; Superior; Janesville, 2 years.

INDIANA, *seven* stations: aggregate, 14 years. Richmond, 4 years; Laporte; South Bend; Green castle.

ILLINOIS, *ten* stations: aggregate, 56 years. Chicago; Alton, 4 years.

IOWA, *eleven* stations: aggregate, 35 years. Pella; Keokuk; Quasqueton.

MINNESOTA, *ten* stations: aggregate, 50 years. St. Paul; Red Lake; St. Anthony; St. Joseph's.

NEBRASKA, &c., *seven* stations: aggregate, 24 years.

NEW MEXICO, *thirteen* stations: aggregate, 38 years. Taos; Abiquiu; Cantonment Burgwin.

CALIFORNIA, *sixteen* stations: aggregate, 55 years. Fort Tejon; Los Angeles, Lieut. Whipple.

OREGON, *twelve* stations: aggregate, 34 years.

CANADAS, AND BRITISH AMERICA in temperate latitudes, *forty-three* stations; aggregate, 178 years. Hamilton, 7 years; Toronto (winter months), 12 years.

RUSSIAN AMERICA, *three* stations: aggregate, 25 years.

Total in UNITED STATES, 583 stations: aggregate of the periods, 4065 years.

Total in TEMPERATE LATITUDES, 639 stations: aggregate of the periods, 4268 years.

The stations above named, the results of which are not published, are generally of short periods, and not indispensable in the present purpose, though a few manuscript series of great value are among them. All were included in the tables prepared by the author as the basis of the isothermal illustration constructed at the Smithsonian Institution in 1853.

The supplemental table of summaries for the seasons only, affords the opportunity to introduce many stations which would not give averages of so much value for the single months. If space permitted the printing of all in detail, and for the monthly means of each year, that course would be very desirable, though the summaries are of far greater value than anything else, and a few tables of extended periods suffice to exhibit the succession of changes, and the measure of variability.

The tables designed to give the temperature history of the observed portions of the United States for the longest possible periods, have not been corrected for horary variation of the observed hours; the results in all cases being in the precise state given them by the original authority. The temperature summaries are similarly given, and in regard to the corrections required for various parts of the United States it is certain that those hitherto deduced, of which the scale for Toronto is the principal, are applicable only to limited districts, and greatly diminish the value of many of the series at remote points. The hours of observation generally represented the true temperatures very nearly in the Military and New York Academy systems, from which most of the statistics are made up.

Previous to 1848 the observations are mainly confined to the United States east of Fort Gibson and Fort Leavenworth, or of the 95th meridian of longitude, and in this district the following points and cities may be selected, when observations have been taken at them, as representatives of the climate of the several divisions or minor districts; Eastport (Fort Sullivan), Houlton (Hancock B'ks), Bath, and Port-

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land (Fort Preble), Maine; one or another alternately. Boston, Newport, Rhode Island; New York City, Albany, and Rochester; Montreal and Toronto; Pittsburg and Philadelphia; Baltimore and Annapolis; Washington; Richmond and Norfolk; Charleston; St. Augustine, Key West, and Pensacola; Mobile, New Orleans, Fort Gibson, St. Louis, Cincinnati, Detroit, Mackinac, Fort Snelling, and Fort Leavenworth.

If any considerable error exists in the tables at these points it is easy to detect it by comparing records in that vicinity of the same date, and nearly all these have been so compared. They may be relied upon as showing, with greater accuracy than is usually supposed to belong to this kind of observation, the distribution of heat geographically, and in time.

This series of tables is intended as a practical basis of comparison for different districts and for successive years, and to make it available as such, it may be briefly stated what certain measures of temperature may be taken to represent. The averages for the spring and autumn are generally very nearly like those for the year—the spring being warmer in the west and south, and colder in the north and east than the year, and the autumn is usually two to five degrees warmer everywhere. Where the average temperature for the spring is 70° or over, the climate is nearly or quite tropical; from this measure to a mean of 50°, the best part of the United States is passed over, nearly to the latitude of Boston. At lower temperatures than 50° the climates are the coldest of the United States, and there is scarcely any vegetation until May.

The corresponding divisions of summer are over 80° for the tropical, from 80° to 65° for the temperate, and below 65° for the colder portions. In autumn, the differences are like the spring. In winter, the tropical or semi-tropical districts, where vegetation does not cease, have an average temperature above 55°; and there is more or less vegetation in these months to the latitude of Norfolk, with a mean temperature of 40°; from this point to the latitude of New York, which has a mean of 32°, there is little snow on the ground, generally; north of this line snow lies regularly most of the winter, and the average temperature varies from 32° at New York to 15° at Fort Snelling, and 11° in Northern Maine.

To compare the quantities for any month or other period with averages for the same period, it may be borne in mind that a difference of 5° for a month, either way, is a large difference, and the extreme of difference in summer; while in winter 10° is an extreme difference. For the year, 5° either way is an extreme difference; that is, a year 5° colder or warmer than the average is probably the coldest or

warmest in any period of twenty-five years; and so of the differences of the months just referred to.

In the greater part of the United States there is a regular curve of differences in the successive months of the year, as follows: January is coldest; February 2° to 4° warmer; March 8° to 10° warmer than February; April 10° warmer than March, and nearly at the mean for the spring, and also for the year; May 9° to 12° warmer than April; June 7° to 9° warmer than May; July 4° to 6° warmer than June; August 1° to 3° less than July; September 5° to 8° less than August; October 8° to 10° less than September, and near the mean for autumn and for the year; November 10° to 14° less than October; and December 10° to 15° less than November. This curve diminishes at the south and in the tropical and semi-tropical districts, and it is less on the Atlantic coast than in the interior; less sharp also about the great lakes, and increasing rapidly in its measures of difference west and north towards the interior. A central belt from Norfolk and Baltimore westward has a greater range of regular and irregular differences than the country north and east, which is generally colder.

By a ready inspection of these tables it may be seen what month or other period of the last thirty-six years was distinguished by either cold or heat, or what its measure of difference was—and whether this peculiarity was general also, or confined to any one part of the United States. Each of the continued and complete series will show what the range generally is at that point, and the table of averages for all points, and for periods of different length, giving the best mean obtainable for the point of observation, will present a basis for comparing each item for any month or year.

The table of mean temperatures at each point for the entire period observed, gives a basis of constant quantities very near to accuracy, and where the period exceeds twenty years no considerable change would be made by any additional number. The results may be appropriately designated the Physical Constants of Distribution of Heat; and, as represented by the isothermal lines, they may be taken as fixed quantities from which all irregular changes may be measured by the degrees of difference presented by the record for any month or year.

In considering the question of permanence of climate some comparison of the periods recorded here will be made. It may here be said that 1824, 1825, 1828, and 1830 were, for some part of each, conspicuously warm; 1831, 1834, 1835, 1836, 1837, 1852, &c. were distinguished as cold; and a series from 1844 to 1848, including some portion of 1853 and 1854, also were distinguished as warm.

The second general tables give the average quantities of rain, or of water falling in rain or snow, in an arrangement similar to the first in all respects. They form the basis of the hyetal or rain illustration, as the first do the basis of the isothermal charts. The longitudes only are omitted, as being in most cases unnecessary, because the same stations appear in the first tables. When they do not, the position is still sufficiently designated for the present purpose. The European stations are here mainly from Dove's memoir in *Poggendorff's Annalen* for January, 1855; the dates and precise authority are unfortunately not given in the original tables. Many other European series are found repeated in other publications without these items, and no alternative exists but to use them as found. They are generally of long periods, and doubtless approach very near to accuracy as expressions of the fixed or true average condition in this respect. Statistics of this sort have heretofore been extremely meager in treatises on Climatology, and no general collection appears to have been made in Europe before this recent one of Dove. The extensive series observed at many European cities are, therefore, scarcely to be found in their original shape, and with proper note of authorities and of the conditions under which the observations were made.

Notes.

The mean temperatures in the following tables are principally obtained from the simple arithmetical mean of the several daily observations, and without correction by any scale derived from the daily curve of temperature. In nearly all cases the observations were taken at hours which represent the true mean very nearly; the principal sets being 7 A. M., 2 P. M., and 9 P. M.; sunrise, 9, 3, and 9; 6, 2, 10; 6, 12, 6; 8, 8; 9, 9; the daily extremes, &c. Reference to the hours is made only when it is thought important to name them.

The United States military posts were observed at 7, 2, 9, until 1843; at sunrise, 9, 3, 9, subsequently to 1854, when the first set of hours was resumed. The New York Academy system was, for nearly the whole of the first 25 years, computed by the formula; $4 = \frac{a+2b+2c+a'}{6}$; in which a is the morning observation, 6 or 7 A. M.; b the midday observation, 2 to 3 P. M.; c that at 9 P. M.; and a' that at 6 the next morning. Prof. Dewey has shown, by a very thorough examination and comparison of observations, that in New York, results so computed, do not differ sensibly from the arithmetical mean of observations at 7, 2, and 9; and Prof. Ray has shown the same for an extended series at Cincinnati. The investigations of Prof. Dewey in hourly observation in 1814 to 1816, founded the choice of the best set of hours, 7, 2, 9, and fortunately, adapted nearly all American observations to forms which require no correction.

The precise relations of the horary curve of temperature were examined by the author in 1853 to ascertain whether the hours could be simplified from the forms then in use; the hourly observatory results at Toronto, Philadelphia, and Washington were projected, with hourly observations from the coast survey at Key West, Mobile, and Galveston; and with some others from surveys and other sources in the interior, at El Paso, and other points. In all cases, the hours 7, 2, 9, best represented the mean

of the 24 hours; 6, 2, 10, and sunrise, 9, 3, 9, were next, and sufficiently near for most purposes. The daily extremes were correct only in the middle latitudes, being much in error in Canada, and at parts of the gulf coast. As the result of this discussion, the author prepared the complete form adopted by the Regents of the New York University and the Smithsonian Institution in 1853, and by the Surgeon-General's Office in 1855. Though sometimes giving averages too high for particular localities, and generally a little too great for the summer months in the United States, it is much more nearly correct than any other which may be used for simultaneous observation over the entire area of the United States.

In British America, Dove's formula for Toronto, deduced from the observatory records there, has been applied by Richardson to all the series. In the west and north the daily curve differs widely from the low range recorded at Toronto, and this scale of corrections is scarcely applicable there in any general sense. The daily extremes give too low a mean in Canada, and too high a mean at the Pacific coast.

Several series are quoted from Dove's tables to afford comparisons, and means of verification, and in some cases the American authority from which he had derived them has escaped observation and is also quoted from him.

Reference Notes.

[1] The observations at the points named in Labrador are irregular; each begins in 1777; that at Okak in August, continuing to September, 1778, and again from August, 1779, to July, 1780. At Nain, observations are continuous from August, 1777, to August, 1780. Dove's series at the last point is a combination of this, with a series beginning in September, 1841. In 1778 and 1779, the mean of the earlier months was very low, and in 1780 very high for the same months. For January and February the mean temperature in 1780 was 25° to 28° higher than in the two previous years.

[2] This includes 1828, 1832, and 1833; with the records at Vermont University.

[3] This extensive series was observed at *sunrise*, 2 *P. M.*, *sunset*, and 10 *P. M.*, from 1813 to 1842; at *sunrise*, 9, 3 and 9, subsequently to August, 1853; and then at 7, 2, 9. The comparison of results through the entire series shows but little if any excess for the first thirty years, and though a correction would usually apply, reducing the averages derived from these hours, so slight a reduction appears to be required here that none has been applied. The daily curve is not sharp here, the open sea and nearness of the gulf stream softening the local climate.

[4] The hours of observation are not given for this series; they are evidently not such as correctly represent the mean, and there are many inaccuracies in it as printed by Darby.

At Washington, the observation by Mr. Meigs, then of the General Land Office, are reliable, though the hours are not known. A series kept through parts of 1822–23 and 24, by Jules De Wallenstein, of the Russian embassy, gives mean results much too high. Mr. Meigs's record was illustrated by a fine colored drawing over twenty feet in length, prepared and presented to Mr. Jefferson, now the property of Colonel Randolph, of Washington.

[5] The first series at Charleston was communicated by Dr. Lining to C. Mortimer, M. D., and the paper read to the Royal Society, May 6, 1748. The means are derived from "the mean nocturnal heat," and the mean at 2 or 3 P. M. "Near eight years' observations" are there said to give an annual mean temperature of 65.5°.

[5'] At Savannah, the record begins in June, 1832, and is omitted from June, 1834, to July, 1836: the hours were 7, 2, 7, to 1851; afterwards 6, 2, 10, and 7, 2, 9. Corresponding years differ very little from the record at *s*. 9, 3, 9, at the military post.

[6] At St. Augustine, 1835, '47, '48, and 1850, are wholly omitted; with parts of 1824, '27, '29, '36, '40, '46, '49, and 1852.

[7] At the Military Post of New Orleans many omissions occur from 1828 to 1837; the entire years 1829 to '31, 1836 and '37; and most of the summer months from 1843 to 1854. The series by Dr. Barton was taken in a position very carefully protected from radiation.

The earlier summer removals were to the Bay of St. Louis, but for recent years this encampment has been at points further east, and near Pascagoula, Miss.

[8] At Corpus Christi, only the summer months were regularly observed.

[9] Yukon River is in Russian America, flowing northwestward. These observations are quoted by Richardson without reference to date or authority. They were taken at 6 A. M. and 6 P. M. in summer, and at the extreme hours of daylight in winter. Dove's correction from the Toronto scale is applied. At Fort Simpson, the observations began in October, 1837; October, 1838, and July to October, 1839, are omitted; closing with June, 1840. (Jameson's Edinb. Phil. Jour. 1841.)

[10] This result is from seven months' observations in 1850, by Captain Stansbury; December, 1853, to April, 1854, by Captain Beckwith; and November, 1854, to March, 1855, at a new military post.

[11] These observations were irregular, and the means are generally too high.

[12] In addition to the years named at San Francisco, there are records from October, 1847, to February, 1848, and from March to June, 1850, embraced in the mean.

[13] The dates at Monterey are May, 1847, to August, 1848; May, 1849, to December, 1850, and July, 1851, to July, 1852.

[14] At Fort Yuma from December, 1850, to April, 1851, in addition to the date named.

[15] At Fort Massachusetts from September, 1852, to September, 1853, and from May, 1854, to May, 1855.

[16] At Santa Fe some months are omitted in 1850, and the period from August, 1851, to August, 1852.

TABLE OF MEAN TEMPERATURES FOR

FROM OBSERVATIONS FOR A PERIOD OF YEARS AT EACH

STATIONS.	Jan.	Feb.	Mar.	Apl.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
	°	°	°	°	°	°	°	°	°	°	°	°	
Hebron, Labrador	—5.1	—0.1	9.9	21.7	32.7	41.5	47.4	48.0	39.9	29.6	19.4	3.8	1
Hebron, Labrador	—5.2	—5.3	4.6	16.8	33.0	36.6	43.6	49.1	38.8	29.4	23.6	5.2	2
Okak, Labrador	2.1	2.0	8.2	29.0	38.2	44.7	51.7	52.0	45.9	31.2	22.4	8.5	3
Nain, Labrador	—4.3	—4.8	6.4	27.7	37.2	43.4	50.5	51.8	44.8	33.0	22.7	7.8	4
Nain, Labrador	—2.9	—0.7	7.6	22.7	32.8	41.8	48.2	51.1	42.2	32.2	22.3	3.4	5
St. John's, Newfoundland . .	23.3	20.9	24.2	33.4	39.3	48.0	56.2	57.9	53.0	44.5	34.0	25.3	6
Charlotte Town, Pr. Edward's Is'd	17.9	23.5	27.8	37.6	51.6	60.2	70.5	67.7	59.5	45.8	37.5	28.6	7
Albion Mines, Pictou, Nova Scotia	18.8	19.4	27.1	37.3	48.5	58.3	66.1	65.6	56.3	46.5	36.0	32.7	8
Halifax, N. S.	22.6	23.7	30.9	38.9	48.0	56.0	62.0	64.4	58.4	48.0	38.5	27.7	9
Fredericton, New Brunswick .	17.0	24.0	33.0	40.0	37.0?	48.5?	65.5	69.7	61.5	47.5	31.1	13.5	10
Quebec	11.0	14.8	28.3	39.4	53.6	65.3	71.3	70.8	57.5	43.7	34.3	12.6	11
Quebec	9.9	12.8	24.4	38.7	52.9	63.7	66.8	65.5	56.2	44.1	31.5	17.3	12
Fort Coulonge, Ottawa River .	11.6	15.7	28.7	40.6	54.4	65.4	69.4	66.5	56.3	45.0	31.3	17.0	13
Montreal	15.0	17.4	29.4	43.5	58.1	68.4	73.1	70.8	60.6	46.5	33.7	19.1	14
St. Martin's, near Montreal . .	14.5	15.4	25.1	39.4	55.7	65.2	72.3	67.5	58.7	45.4	32.2	17.4	15
Montreal	14.0	16.1	27.5	40.0	53.4	66.0	69.7	66.2	58.5	45.1	32.3	18.7	16
Montreal	15.0	19.2	31.0	45.8	60 5	69.2	73.6	71.4	61.1	48.7	34.4	19.1	17
Fort Kent, Maine	11.1	11.6	23.5	35.3	46.8	59.0	62.5	63.5	51.6	49.1	28.0	11.3	18
Houlton, Hancock Banks, Me. .	14.7	16.4	27.6	39.4	50.5	60.3	65.2	64.5	55.2	43.4	30.8	18.1	19
Eastport, Fort Sullivan, Me. .	22.4	23.5	30.8	40.4	49.2	56.7	62.3	62.4	57.3	47.9	37.3	25.8	20
Castine, Me.	21.4	22.5	30.4	41.4	50.3	59.4	64.8	64.7	58.4	48.4	38.0	25.6	21
Saco, Biddeford, Me. . . .	20.9	22.6	32.5	43.4	53.8	66.1	70.8	69.4	60.9	48.0	38.2	24.7	22
Bath, Me.	23.2	23.3	31.1	41.7	52.2	61.4	68.5	64.6	59.2	47.7	35.9	25.1	23
Portland, Fort Preble, Me. . .	22.8	24.5	32.5	42.9	52.8	63.1	68.2	66.4	56.9	49.7	37.8	26.8	24
Portland, Marine Observatory .	19.6	21.2	30.0	40.2	50.2	59.5	66.1	64.6	57.5	46.1	35.4	24.1	25
Portsmouth, Ft. Constitution, N. H.	24.9	26.2	33.7	42.9	53.0	61.0	67.1	65.1	58.9	49.5	38.7	28.6	26
Dover, N. H.	23.5	23.6	31.8	42.7	53.7	63.8	70.1	66.7	58.8	46.4	35.5	25.2	27
Concord, N. H.	21.2	21.9	30.7	42.4	54.8	63.4	67.1	65.6	56.5	48.4	37.0	25.0	28
Hanover, Dartmouth College .	15.8	15.2	25.6	37.6	51.2	61.6	64.4	62.3	55.0	43.1	31.3	17.2	29
Williamstown, Vermont . .	15.5	15.7	25.4	38.2	50.3	59.4	64.0	61.4	53.0	41.8	30.1	18.1	30
Fayetteville, Vt.	18.9	19.3	30.7	43.3	54.4	64.5	67.3	66.5	56.9	46.9	35.6	24.4	31
Burlington, Vt.	20.5	20.4	31.0	42.0	55.2	64.9	69.9	68.0	59.6	47.6	36.1	23.9	32
Andover, Mass.	24.5	26.0	32.7	45.3	56.1	66.6	70.4	69.0	61.3	49.2	37.4	30.1	33
Salem, Mass.	25.6	27.7	35.4	46.0	56.8	67.2	72.5	70.5	63.0	51.3	40.0	30.3	34
Mendon, Mass.	26.0	24.0	33.3	45.6	55.0	64.6	71.9	68.7	61.0	48.9	39.1	27.6	35

EACH MONTH, SEASON, AND THE YEAR;

STATION, IN THE UNITED STATES AND BRITISH AMERICA.

	Spng.	Sum.	Aut.	Wint.	Year.	Yrs. and mos.	Date.	POSITION OF STATION. Lat.	Long.	Alt.	AUTHORITY.
	°	°	°	°	°			° ′	° ′	Ft.	
1	21.4	45.6	29.8	—0.5	21.6	6	1777–	58.00	63.30	50 ?	*Dove*, (6 to 7 a. m.; 12; 6 to 7 p. m.).
2	18.2	43.1	30.6	—1.8	22.5	2	Aug. 41–Jul. 43	58.00	64.00	50 ?	*Dove, Lamont's Ann.* [12, 4, 8; uncor.)
3	25.1	49.5	33.2	4.2	28.0	2–2	1777–1780[1]	57.30	63.00	?	De la Trobe, *Phil. Trans.*, 1779–81 (8,
4	23.8	48.6	33.5	—0.4	26.4	3–1	1777–1780	57.10	61.50	50 ?	De la Trobe, do. (8, 12, 4, 8; uncor.)
5	21.7	47.0	32.2	—0.4	25.1	9–6	1777–	57.10	61.50	50	*Dove* (7–8, 12, 4–5½).
6	32.3	54.0	43.8	23.2	38.3	5	1834–1838	47.33	52.43	140	Templeman, *Am. Jour. Sci.*, (d. ex.)
7	39.0	66.1	47.6	23.3	44.0	1	....	46.12	63.00	?	*Dove, Climate N. A.*, 1856.
8	37.6	63.3	46.3	20.6	42.0	10	1843–1852	45.34	62.42	50 ?	Poole, *MS.*
9	39.3	60.8	48.3	24.7	43.2	7–3	....	44.39	63.37	20	*Dove*, (6, 3, 8; reduced.)
10	40.0	64.6	46.7	18.2	42.4	1	....	46.03	66.08	..	*Martin, Brit. Col., Dove.*
11	40.4	69.1	45.2	12.8	41.9	3	1845–1847	46.49	71.16	100	*Richardson, Old Parl't House Record.*
12	38.6	65.3	44.0	13.3	40.3	10	....	46.49	71.16	300	Rev. Dr. Sparks, *Latour MS.*
13	41.2	67.1	44.2	14.7	41.8	8	....	45.50	77.52	250	Siveright, *Latour MS.*
14	43.7	70.8	46.9	17.2	44.6	27	....	45.31	73.34	60 ?	Dr. Hall, *MS.* (several observers).
15	40.1	68.3	45.6	15.7	42.4	4	1852–1855	45.32	73.36	118	Smallwood, *Can. Jour. Sci.* (6, 2, 10).
16	40.3	67.3	45.3	16.3	42.3	5	1836–1840	45.31	73.34	90	McCord, (daily extremes); *Drake.*
17	45.7	71.4	48.1	17.8	45.7	10	1826–1835	45.31	73.34	50	Hall, (9, 3); *Phil. Mag.*
18	35.2	61.7	39.9	11.3	37.0	4	1842–1845	47.15	68.35	575	U. S. Military Post.
19	39.1	63.3	43.2	16.4	40.5	17	1829–1845	46.07	67.49	620	Mil. Post.
20	40.2	60.5	47.5	23.9	43.0	25	1822–45; 49–53	44.54	66.58	100 ?	Mil. Post.
21	40.7	62.0	48.3	23.2	43.4	40	1811–1850	44.23	68.47	40	—— *MS.*
22	43.2	68.8	49.0	22.8	45.9	8	Jul. 43–May 51	43.31	70.26	69	Batchelder, Garland, *Am. Al.* (7, 2, 7).
23	41.7	64.8	47.6	23.9	44.5	10–6	1832–Jul. 1842	43.50	69.52	20	Hayden, *Am. Alm.*
24	42.8	65.2	48.1	24.7	45.2	22	1824–35; 41–53	43.39	70.20	20	Mil. Post.
25	40.1	63.4	46.3	21.6	42.9	31	1820–1850	43.40	70.14	50	Beckett, *Agl. Rep.*
26	43.2	64.4	49.0	26.6	45.8	25	1825–45; 49–53	43.04	70.49	20	Mil. Post.
27	42.7	66.9	46.9	24.1	45.2	10–6	1833–1843	43.10	70.54	150	Tufts, *Am. Alm.*
28	42.6	65.4	47.3	22.7	44.5	10	1828–1837	43.13	71.29	250 ?	Farmer, *Am. Alm.* (S., 2, 9).
29	38.1	62.8	43.1	16.1	40.0	3	Nov. 1834–Oct. 37	43.43	72.18	450	Young, *Am. Alm.*
30	38.0	61.6	41.6	16.4	39.4	13	1829–1841	44.07	72.32	1590	E. Paine, *Hist. Vermont*, (8, 1, 9).
31	42.8	66.1	46.4	20.9	44.1	6	May 1827–Apl. 33	42.58	72.35	400 ?	Field, *Am. Jour. Sci.* (S., 2, 9).
32	42.7	67.9	47.8	21.6	45.0	21	1838–1855[2]	44.29	73.11	367	Thompson, *Hist. Vt.*, &c.
33	44.7	68.7	49.3	26.9	47.4	11	1798–1808	42.40	71.08	150 ?	French, *Mems. Am. Acad.*, Vol. III.
34	46.1	70.1	51.4	27.9	48.9	43	1786–1828	42.31	70.54	30	Holyoke, *Mems. Am. Acad.*
35	44.6	68.4	49.7	25.9	47.2	17	1833–47; 54–55	42.06	71.31	200 ?	Metcalf, *Alm.*, &c.

TABLE OF MEAN

STATIONS.	Jan.	Feb.	Mar.	Apl.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
	°	°	°	°	°	°	°	°	°	°	°	°	
Cambridge, Mass.	29.0	31.2	37.1	48.0	58.7	67.2	72.9	70.9	62.0	51.6	41.1	31.9	1
Cambridge, Mass.	28.0	30.7	36.5	48.5	58.5	68.5	73.7	73.3	64.0	50.7	37.0	31.5	2
Cambridge, Mass.	22.5	23.9	32.9	45.1	54.4	66.1	69.6	69.4	60.0	50.1	40.2	29.1	3
Cambridge, Mass.	25.6	27.3	35.8	[illegible]	57.1	67.7	73.1	70.9	62.3	50.2	38.9	29.6	4
Cambridge, Mass.	23.1	24.7	32.5	45.4	54.2	64.6	68.5	69.3	60.9	51.2	39.1	29.7	5
Cambridge Observatory . .	25.5	25.0	33.7	44.1	55.0	65.8	71.5	68.5	61.3	49.6	39.3	28.1	6
Boston, Mass.	26.6	27.8	35.8	45.9	56.6	65.9	71.9	69.2	61.8	50.9	39.7	30.5	7
Boston, Mass.	27.8	27.9	36.2	46.4	56.5	66.2	71.6	69.4	62.2	51.5	41.0	31.1	8
Fort Independence, Boston Harbor	26.8	27.7	35.4	45.6	57.0	65.6	71.1	69.1	62.8	53.0	41.5	31.4	9
Medfield, Mass, ...	23.9	26.5	34.0	43.9	54.4	64.6	69.2	67.9	59.1	48.9	38.5	31.1	10
Princeton, Mass.	22.9	18.2	27.7	40.2	54.2	62.1	70.3	64.9	58.6	50.5	36.8	23.8	11
Amherst College, Mass. . .	23.7	23.5	33.1	45.6	56.2	65.7	71.0	69.0	60.0	47.7	38.3	26.8	12
Williamstown, College, Mass. .	22.5	20.7	28.7	41.9	54.0	64.1	68.4	66.6	58.4	47.0	39.1	25.5	13
Williamstown, College, Mass. .	22.0	23.6	31.1	43.5	56.2	66.3	70.2	67.2	60.0	47.1	36.6	26.9	14
New Bedford, Mass. . . .	28.4	28.6	35.4	44.5	54.3	63.8	69.4	68.2	61.8	52.0	42.1	32.3	15
Nantucket, Mass..	34.9	30.0	36.7	44.3	52.7	63.6	71.0	68.9	63.4	56.7	48.8	37.2	16
Newport, Fts. Wolcott and Adams	29.5	30.3	36.9	45.4	55.4	65.3	71.1	70.1	63.6	54.0	42.9	34.0	17
Providence, R. I., University .	27.5	26.9	34.7	44.0	55.2	64.9	70.6	68.7	60.9	50.3	39.8	29.8	18
New London, Ft. Trumbull, Ct. .	29.1	29.6	36.1	46.8	56.3	66.1	71.5	70.1	63.3	53.0	42.3	31.1	19
East Hampton, Long Island, N. Y.	30.1	30.7	36.4	44.4	53.2	62.8	69.7	68.5	62.5	52.2	42.3	33.4	20
Jamaica, Long Island, N. Y. .	29.4	29.3	37.6	47.2	57.0	64.9	71.2	70.6	62.0	51.8	41.7	32.5	21
Flatbush, Long Island, N. Y. .	31.5	31.4	40.1	49.1	58.9	67.4	72.7	71.4	64.3	53.5	44.1	35.1	22
Ft. Hamilton, Narrows, N. Y. Har.	31.6	30.9	38.1	44.3	57.8	67.8	73.2	73.0	66.6	55.2	45.6	34.3	23
New York, Fort Columbus . .	30.2	30.4	38.3	48.6	59.3	68.3	74.8	73.2	65.8	54.5	43.3	33.5	24
West Point, N. Y.	28.3	28.8	37.6	48.7	59.8	68.4	73.7	71.8	64.3	53.0	42.2	32.0	25
Kinderhook, N. Y. . . .	22.9	23.3	33.7	46.3	57.3	65.4	70.1	68.5	60.3	47.5	38.3	25.3	26
Albany, N. Y.	24.3	25.4	35.0	47.2	59.6	68.0	72.1	70.0	61.4	49.4	39 2	28.4	27
Watervliet, N. Y.	23.0	23.8	34.0	45.8	58.7	68.2	73.6	70.9	62.1	50.7	38.9	27.1	28
Cherry Valley, N. Y. . . .	22.0	21.7	30.3	43.6	53.8	63.5	67.0	65.6	57.8	45.8	34.4	25.3	29
Utica, N. Y.	23.3	23.4	32.3	44.7	56.4	64.2	68.5	66.7	58.4	47.4	36.2	26.8	30
Potsdam, St. Lawrence Co., N. Y.	18.4	18.8	30.0	43.7	55.0	63.9	68.4	66.7	57.4	45.0	33.7	22.1	31
Auburn, N. Y.	24.4	24.6	33.5	45.3	54.4	63.5	69.8	68.2	59.4	48.2	37.7	29.5	32
Rochester, N. Y.	26.0	26.4	33.1	44.7	56.1	65.0	69.9	67.9	60.3	48.1	38.3	28.5	33
Toronto, Canada	24.3	23.1	30.4	41.3	51.5	61.4	66.8	66.3	58.1	45.2	36.6	26.2	34
Ancaster, Canada	26.2	23.9	33.2	43.5	54.2	61.8	68.5	65.0	57.3	47.6	37.5	27.8	35
Fredonia, N. Y.	28.7	27.4	35.3	46.4	56.6	65.4	70.9	68.8	61.3	50.5	41.3	30.8	36
Pittsburg Arsenal, Pa. . . .	29.1	31.2	39.0	50.0	60.9	69.2	73.0	71.2	63.6	50.9	39.8	31.3	37
Carlisle Barracks, Pa. . . .	29.2	31.0	38.8	50.1	60.4	70.4	74.1	71.9	64.4	52.2	39.5	31.2	38
Lancaster, Pa.	30.1	32.4	40.7	52.1	60.0	68.4	73.4	71.8	64.7	52.1	39.6	32.2	39
Gettysburg, Penna. College . .	27.9	30.5	39.2	50.3	60.6	69.2	74.0	71.6	63.3	49.9	40.1	31.4	40
Germantown, Pa.	30.0	33.1	41.2	49.4	61.3	71.2	75.0	73.0	65.0	53.5	42.6	32.6	41
Lambertville, N. J. . . .	30.4	30.0	38.8	49.5	60.4	69.3	74.7	71.9	63.9	51.6	41.8	32.0	42

TEMPERATURES—Continued.

	Spng.	Sum.	Aut.	Wint.	Year.	Yrs. and mos.	Date.	Position of Station. Lat.	Long.	Alt.	Authority.
	°	°	°	°	°			° ′	° ′	*Ft.*	[not known.)
1	47.9	70.3	51.6	30.7	50.1	33	1742–1774	42.23	71.07	..	Dr. Winthrop, Hawksbee's ther. (hrs.
2	47.8	71.8	50.6	30.1	50.1	3	July 1780–83	42.23	71.07	..	Rev. E. Wigglesworth, *Mems. Am.*
3	44.1	68.4	50.1	25.2	47.0	6	1783–1788	42.23	71.07	..	Dr. Williams, *Am. Al.* [*Acad.*, Vol. I.
4	46.6	70.6	50.5	27.5	48.8	19	1790–1808	42.23	71.07	80	Farrar, *Mems. Am. Acad.*
5	44.0	67.5	50.4	25.6	46.9	7	1809(ex.14,15)-17	42.23	71.07	..	*Am. Alm.*
6	44.3	68.6	50.1	26.2	47.3	15	1841–1855	42.23	71.08	71	Bond, *MS. & Am. Alm.*
7	45.9	69.0	50.8	28.3	48.6	20	1820–1839	42.20	71.03	..	Hall, *Am. Journ. Sci.*, 1842.
8	46.3	69.1	51.6	28.9	48.9	26	1825–1850	42.21	71.03	50	Paine, *Bost. Trav.*
9	46.0	68.6	52.4	28.6	48.9	17	1824–37; 51–54	42.20	71.00	40	Mil. Post.
10	44.1	67.2	48.8	27.2	46.8	10	1821–1830	42.15	71.20	150 ?	Sanders, *Dove.*
11	40.7	65.8	48.3	21.6	44.1	2	1854–1855	42.28	71.53	1133	Brooks, *Agl. Rep.*
12	45.0	68.6	48.7	24.7	46.7	14	1839–50; 54–55	42 22	72.31	267	Snell, *MS. & Agl. Rep.*
13	41.5	66.4	48.2	22.9	44.8	4	1816–1819	42.43	73.13	930 ?	Dewey, *Mems. Am. Acad.*, Vol. IV.
14	43.6	67.9	47.9	24.2	45.9	11	1816–1826	42.43	73.13	930 ?	Dewey, &c., *Mems. Acad.*, *Dove.*
15	44.7	67.1	52.0	29.8	48.4	43–6	1813–1856	41.38	70.56	40	Rodman, *MS.*[3]
16	44.6	67.8	55.3	33.7	50.4	2	1854–1855	41.17	70.06	30	Mitchell, *Agl. Rep.*
17	45.9	68.8	53.5	31.3	49.9	24	1822–35; 42–53	41.30	71.20	30	Military Posts, Newport Harbor.
18	44.7	68.1	50.3	28.1	47.9	23	1832–1854	41.49	71.25	150	Caswell, *Am. Alm.*, &c.
19	46.4	69.3	52.9	29.9	49.6	11	1833 *irreg.* 1853	41.21	72.06	23	Mil. Post.
20	44.7	67.0	52.3	31.4	48.8	17	1827–1843	41.00	70.19	16	*N. Y. Academy Reports.*
21	47.3	68.9	51.8	30.4	49.6	25	1826–1850	40.41	73.56	50	(Do.)
22	49.4	70.5	53.9	32.7	51.6	24	1826–1849	40.37	73.58	40	(Do.)
23	46.7	71.3	55.8	32.3	51.5	12	1843–1854	40.37	74.02	25	Mil. Post.
24	48.7	72.1	54.5	31.4	51.7	33	1822–1854	40.42	74.01	23	Mil. Post (Governor's Island.)
25	48.7	71.3	53.2	29.7	50.7	31	1824–1854	41.23	74.00	167	Military Academy.
26	45.8	68.0	48.7	23.8	46.6	17	1830–1846	42.22	73.43	125	*N. Y. Academy Reports.*
27	46.7	70.0	50.0	26.0	48.2	28	1826–1853	42.31	73.44	130	Beck, &c., *Acad. Rep.*
28	46.2	70.9	50.6	24.6	48.1	31	1824–1854	42.43	73.43	50	Mil. Post (Arsenal).
29	42.6	65.4	46.0	23.0	44.2	15	1827–36; 41–45	42.48	74.47	1335	*N. Y. Academy Reports.*
30	44.5	66.5	47.3	24.5	45.7	23	1826–1848	43.06	75.13	473	(Do.)
31	42.9	66.3	45.4	19.8	43.6	21	1828–1848	44.40	75.01	394	(Do.)
32	44.4	67.2	48.4	26.2	46.8	22	1827–1849	42.55	76.28	650	(Do.)
33	44.6	67.6	48.9	27.0	47.0	24	1830; 33–53	43.07	75.51	506	Dewey and others, *N. Y. Acad. Rep.*
34	41.1	64.8	46.6	24.5	44.3	16	1840–1855	43.39	79.21	341	Lefroy and others, *Mag. & Met. Obs.*
35	43.7	65.1	47.4	25.9	45.6	7	1835–1842	43.15	80.10	?	Craigie, (9, 9); *Ed. Phil. Jour.*
36	46.1	68.4	51.0	29.0	48.6	18	1830–1848	42.26	79.24	709	*N. Y. Academy Reports.*
37	50.0	71.4	51.4	30.6	50.8	22	1825–27; 36–54	40.32	80.02	704	Mil. Post.
38	49.8	72.1	52.1	30.4	51.1	13	1839–46; 48–54	40.12	77.14	500	Mil. Post.
39	50.9	71.2	52.1	31.6	51.4	8	1839–1843	40.02	76.21	300 ?	Atlee, *Jour. Frank. Inst.*
40	50.0	71.6	51.1	30.1	50.7	17	1839–1855	39.48	77.18	600 ?	Jacobs, *MS.*
41	50.6	73.0	53.7	31.9	52.3	9–2	Jun. 1819–Jul. 28	40.03	75.10	70 ?	Haines, *Darby's U. S.* (morn, 12, eve.)
42	49.6	72.0	52.4	30.8	51.2	19	1837–1855	40.23	74.55	96	Parsons, *Am. Alm.*, 1857.

TABLE OF MEAN

STATIONS.	Jan.	Feb.	Mar.	Apl.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
	°	°	°	°	°	°	°	°	°	°	°	°	
Northumberland, Pa.	24.4	31.0	39.5	52.4	61.2	69.2	73.3	71.0	62.7	50.9	38.8	30.6	1
Trenton, N. J.	30.9	32.5	38.8	50.9	58.5	67.7	72.8	71.6	63.4	51.5	41.3	32.6	2
Philadelphia	28.0	37.0	44.0	50.0	62.0	70.0	72.0	70.0	60.0	53.0	39.0	33.0	3
Philadelphia	32.1	35.4	40.4	51.1	59.3	69.6	74.7	73.0	64.0	54.6	43.9	34.7	4
Philada., "cor. 2d and Dock Sts."	32.7	36.3	45.6	57.2	68.1	78.2	82.2	80.6	73.4	60.8	47.6	37.1	5
Philadelphia	30.7	29.7	38.9	49.2	60.7	68.3	73.8	70.2	63.4	52.6	44.5	33.9	6
Philadelphia, Penna. Hospital .	31.8	32.3	41.0	51.8	62.5	71.5	76.0	73.2	63.8	54.5	44.0	34.5	7
Philadelphia, Girard College .	32.4	32.8	42.4	50.6	58.9	68.8	72.8	71.5	64.1	51.3	40.8	32.6	8
Frankford Arsenal	32.4	31.9	41.7	51.1	60.7	69.4	75.4	73.0	66.1	54.0	42.4	33.7	9
Fort Mifflin, near Philadelphia .	33.2	32.2	40.3	50.6	61.5	71.9	76.9	74.4	68.7	55.8	45.5	35.1	10
Fort Delaware, Del.	33.7	35.8	43.0	52.3	65.3	73.8	70.8	70.6	70.9	58.0	46.6	39.3	11
Baltimore, Md.	30.9	33.0	39.2	52.1	60.6	70.9	75.2	74.7	66.6	54.9	44.3	34.4	12
Baltimore, Fort McHenry . .	32.8	34.2	42.3	52.7	63.1	71.6	76.7	74.7	67.8	55.7	45.1	35.6	13
Schellman Hall, Md.	31.5	30.2	41.5	52.4	64.7	70.1	77.3	73.6	69.1	55.4	44.8	32.0	14
Frederick, Md.	32.8	32.0	39.8	52.6	65.2	72.4	79.9	74.8	69.0	53.6	44.5	33.3	15
Annapolis, Ft. Severn, Md. . .	32.3	35.4	42.8	54.1	64.5	72.7	77.2	76.1	68.8	57.6	46.8	36.7	16
Washington City	28.3	43.0	44.2	54.1	64.6	73.9	76.7	77.5	68.8	54.4	44.3	31.3	17
Washington City	34.1	36.7	45.3	55.7	66.3	74.4	78.3	76.3	67.7	56.7	44.8	37.3	18
Washington, Naval Observatory .	31.3	36.7	45.3	54.6	62.6	71.5	75.1	72.7	65.6	54.7	41.5	33.6	19
Alexandria, Va.	31.5	34.3	43.4	53.7	65.3	73.8	78.6	76.0	67.9	53.8	47.0	35.2	20
Fort Washington, Md. . . .	35.5	38.6	46.8	57.1	68.3	76.3	80.0	76.9	69.6	59.8	47.4	38.0	21
Charlottesville, Va.	43.1	30.8	46.5	52.4	59.5	72.2	76.3	74.3	65.2	60.2	48.3	39.2	22
Lewisburg, Va.	35.4	34.2	44.4	53.8	64.9	69.0	77.1	73.9	68.8	53.5	45.0	35.4	23
Richmond, Va.	33.7	39.8	47.1	54.7	65.4	73.8	77.6	74.8	67.1	57.5	44.2	38.1	24
Bellona Arsenal, near Richmond .	38.7	41.9	50.3	58.3	69.3	76.6	79.2	77.9	70.6	60.1	50.6	43.4	25
Williamsburg, Va.	32.9	43.2	46.4	61.2	66.2	77.9	82.2	78.1	70.9	57.2	44.8	38.3	26
Fort Monroe, near Norfolk . .	36.5	41.7	48.3	56.2	66.1	74.2	78.2	77.2	72.0	61.6	51.4	43.1	27
Chapel Hill, N. C.	41.5	43.7	51.1	59.5	67.3	74.7	78.2	75.9	70.5	59.4	51.0	43.3	28
Beaufort, Fort Macon, N.C. . .	45.2	44.1	49.5	60.0	68.9	76.9	79.8	78.9	74.6	64.4	56.5	48.0	29
Smithville, Ft. Johnston, N. C. .	49.0	50.5	56.3	64.2	72.8	78.9	81.5	80.2	76.0	67.1	59.2	52.2	30
Camden, S. C.	45.1	48.5	56.0	61.5	71.4	76.4	80.5	78.4	74.3	61.8	52.6	46.3	31
Berkeley, S. C.	49.1	53.6	57.5	62.4	70.2	74.8	78.8	77.9	73.1	64.1	55.2	52.1	32
Charleston, S. C.	51.0	54.0	59.0	70.0	75.0	79.0	81.0	79.0	73.0	62.0	53.0	51.0	33
Charleston, S. C.	48.1	54.4	59.7	64.9	73.1	79.8	80.1	79.4	74.3	66.7	58.6	51.8	34
Charleston, Fort Moultrie . .	50.3	52.4	58.7	65.4	73.4	79.0	81.7	80.9	76.9	67.9	59.5	52.5	35
Augusta, Georgia	46.7	50.7	55.8	65.1	72.2	79.0	81.9	79.7	72.8	63.5	53.8	46.8	36
Sparta, Ga.	46.3	45.2	56.7	61.7	72.3	76.2	81.6	79.6	76.3	61.2	54.9	45.0	37
Athens, Ga., University . .	45.5	47.1	55.0	64.0	69.1	75.4	77.4	76.8	73.5	59.7	51.0	50.1	38
Savannah, Ga.	52.2	54.5	60.4	67.7	74.8	79.6	81.9	81.1	76.9	67.2	58.6	51.5	39
Savannah, Barracks . . .	54.4	55.0	58.6	67.1	75.5	79.8	81.4	80.8	77.0	67.1	59.7	52.7	40
Whitemarsh Island, Ga. . .	49.2	52.9	59.0	65.0	72.6	76.9	80.2	80.0	75.4	65.9	57.5	51.6	41
Perry, Ga.	39.8	55.1	63.2	62.9	74.1	78.2	82.3	78.8	74.8	67.6	53.3	50.9	42

TEMPERATURES—Continued.

	Spng.	Sum.	Aut.	Wint.	Year.	Yrs. and mos.	Date.	Position of Station. Lat.	Long.	Alt.	Authority.
	°	°	°	°	°			° ′	° ′	Ft.	
1	57.0	71.2	50.8	28.7	50.4	3	1839–1841	40.52	77.00	400	*Jour. Frank. Inst.*
2	49.4	70.7	52.1	32.0	51.1	5	1840–1844	40.13	74.45	50	Ewing, (S., 2, 10); *Am. Alm.*
3	52.0	70.7	50.7	32.7	51.5	1	1748–1749	39.58	75.12	75 ?	Bartram, Kalm, *Travels in N. A.*
4	50.3	72.4	54.2	34.1	52.7	13	1758–59; 67–77	39.57	75.13	40	*Trans. Am. Phil. Soc.*, 1839.
5	56.9	80.3	60.6	35.4	58.3	20	1807–1826	..	..	20	Young, *Darby.*
6	49.6	70.8	53.5	31.4	51.4	10	1829–1838	39.56	75.12	30	Hewson, *Trans. Phil. Soc.*, 1839.
7	51.8	73.6	54.1	32.9	53.1	32	1825–1856	39.56	75.12	40	Conrad, (daily ex.); *Phil. Inq.*
8	50.6	71.0	52.1	32.6	51.6	4–9	1840–1845	39.57	75.13	60	Bache, *Mag. & Met. Obs.* (bi-hourly).
9	51.2	72.6	54.2	32.7	52.7	8	1836–1843	40.01	75.12	20	Mordecai, *Jour. Frank. Inst.* (bi-hr.)
10	50.8	74.4	56.6	33.5	53.8	10	1823 *irreg.* 1853	39.53	75.13	20	Mil. Post. (1823–24; 43–46; 49–53).
11	53.5	75.9	58.5	36.3	56.1	6	1825–1830	39.35	75.34	10	Mil. Post.
12	50.6	73.6	55.3	32.8	53.1	8	1817–1824	39.18	76.36	80 ?	Brantz, (S., 2, 10).
13	52.7	74.3	56.2	34.2	54.3	24	1851–1854	39.17	76.35	36	Mil. Post.
14	52.9	73.7	56.4	31.2	53.6	2	1854–1855	39.23	76.57	700	Baer, *Agl. Rep.*
15	52.5	75.7	55.7	32.7	54.1	2	1854–1855	39.24	77.18	700 ?	Hanshaw, *Agl. Rep.*
16	53.8	75.3	57.8	34.8	55.4	8	1822; 31–4; 43–5	38.58	76.27	20	Mil. Post.
17	54.3	76.0	55.8	34.2	55.1	2	1820–1821	38.53	77.01	50	Meigs, *MS.*
18	55.8	76.3	56.4	36.1	56.1	13	1823–1835	38.53	77.02	80	Little & Brereton, *Army Met. Reg.*
19	54.2	73.1	53.9	33.9	53.8	3–8	Nov. 38–Jun. 42	38.53	77.01	78	Gillis, *Mag. and Met. Obs.*
20	54.1	76.2	56.2	33.7	55.0	3–1	1853–Jan. 56	38.50	77.10	50	Hallowell & Miller, *MS.*
21	57.4	77.4	58.9	37.3	57.8	15	1824–35; 51–53	38.43	77.06	60	Mil. Post.
22	52.8	74.3	57.9	37.7	55.7	1	Jul. 37–Jun. 38	38.02	78.23	150 ?	*Am. Alm.* (S., 2).
23	54.4	73.3	55.8	35.0	54.6	2	1854–1855	37.49	80.28	1800 ?	Patten, *Agl. Rep.*
24	55.7	75.4	56.3	37.2	56.2	4	1824–1827	37.04	77.31	120 ?	Chevallie, *Darby's U. S.*
25	59.3	77.9	60.4	41.4	59.7	10	1824–1833	37.20	77.25	120	Mil. Post.
26	58.1	79.4	57.6	38.2	58.3	13	1775–	37.05	81.40	150	*Cotte, Dove.*
27	56.9	76.6	61.7	40.4	59.9	30	1825–1854	37.00	76.18	8	Mil. Post.
28	59.3	76.3	60.3	42.8	59.7	14	1820–22; 44–55	35.54	79.17	570	Caldwell, Phillips.
29	59.5	78.5	65.2	45.7	62.2	5	1833–36; 43–44	34.41	76.40	20	Mil. Post.
30	64.5	80.2	67.4	50.6	65.7	18	1822–1845	34.00	78.05	20	Mil. Post.
31	63.0	78.4	62.9	46.6	62.7	6	1850–1855	34.17	80.33	275	Carpenter, *MS.;* Young, *Agl. Rep.*
32	63.4	77.2	64.1	51.6	64.0	9	1845–1853	33.15	80.00	100 ?	Ravenel, *Jour. Bl'k Oak Agl. Soc.*
33	68.0	79.7	62.7	52.0	65.6	4	1738–40; 1742	32.45	79.57	30	Dr. Lining, *Phil. Trans.* 1748, (d. ex.).
34	65.9	79.8	66.5	51.4	65.9	10	1750–1759	32.45	79.57	20	Dr. Chalmers, *Weath. & Dis. of S. C.*
35	65.8	80.6	68.1	51.7	66.6	28	1823–35; 40–54	32.45	79.51	20	Mil. Post (Sullivan's Island).
36	64.4	80.2	63.4	48.1	64.0	21	1826–1846	33.28	81.53	550	Mil. Post ("300 ft. ab. Augusta").
37	63.6	79.1	66.1	45.5	63.1	2	1854–1855	33.17	83.09	550 ?	Pendleton, *Agl. Rep.*
38	62.7	76.5	61.4	47.6	62.1	4–6	1845–Jun. 1849	33.55	83.25	870	McCoy, *Southern Cult.* (S., 3 p. m.)
39	67.6	80.9	67.6	52.7	67.2	21–6	1832–34; 36–55	32.05	81.07	45	Oemler, Posey, *Am. Alm.* (7, 2, 7; 7,
40	67.1	80.7	67.9	54.0	67.4	9	1832–35; 43–46	32.05	81.07	25	Mil. Post. (Oglethorpe Bks.) [2. 9).
41	65.5	79.0	66.3	51.2	65.5	6	1849–1855	32.00	81.00	18	Gibson, (ex. 1852); *MS.* & *Agl. Rep.*
42	66.7	79.8	65.3	48.6	65.1	2	1851–1852	32.30	83.42	200 ?	Cooper, *MS.*

TABLE OF MEAN

STATIONS.	Jan.	Feb.	Mar.	Apl.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
	°	°	°	°	°	°	°	°	°	°	°	°	
St. Augustine, Fla. . . .	57.0	59.9	63.3	68.8	73.5	79.3	80.9	80.5	78.6	71.9	64.1	57.2	1
Jacksonville, Fla.	56.4	56.1	64.2	67.8	76.4	79.4	82.3	82.4	80.7	68.7	64.1	54.2	2
Pilatka, Fort Shannon, Fla. . .	57.2	58.3	64.1	71.2	76.6	80.3	81.2	80.2	78.6	70.5	61.5	56.0	3
New Smyrna, E. Fla. . . .	62.4	63.7	67.6	73.6	74.2	78.8	79.8	78.8	78.2	72.0	67.2	63.5	4
Fort Pierce, E. Fla. . . .	62.7	64.4	69.8	73.6	76.9	79.0	82.5	82.4	80.8	75.0	68.5	62.6	5
Cape Florida, Fort Dallas . .	66.4	66.6	70.4	75.6	78.0	80.5	82.1	81.8	79.6	77.9	71.3	66.8	6
Key West	66.7	68.9	72.9	75.4	79.1	81.6	83.0	82.9	81.9	78.1	74.7	71.0	7
Key West	69.5	70.0	72.6	75.2	78.9	81.2	82.5	82.7	81.3	77.4	74.7	70.5	8
Fort Myers, Fla.	63.4	68.0	72.2	73.8	80.1	81.2	82.9	83.1	81.7	77.7	71.5	64.7	9
Tampa Bay, Fla., Fort Brooke .	61.5	63.5	67.7	71.8	76.6	79.5	80.7	80.4	78.3	74.0	66.9	62.0	10
Fort Meade, Fla.	58.4	63.2	69.0	69.9	76.7	78.2	79.8	80.0	79.2	73.8	68.5	61.1	11
Micanopy, Fla.	60.5	60.5	67.4	72.0	76.6	79.3	80.0	79.3	77.9	70.5	61.0	56.0	12
Fort King, Fla.	58.5	58.2	64.3	71.4	76.4	79.8	80.8	80.1	78.2	70.6	63.2	58.5	13
Cedar Keys, Fla.	58.5	59.5	65.7	69.8	74.7	77.6	80.3	79.4	79.0	71.8	62.3	57.7	14
Cedar Keys, Fla.	55.6	58.3	68.4	68.7	76.9	79.7	81.3	81.4	79.7	72.5	64.3	59.1	15
Fort Fanning, Fla.	59.7	58.3	67.0	70.6	75.7	79.1	81.6	82.2	80.4	72.1	60.6	55.0	16
Fort Morgan, Mobile Bay . .	55.2	50.2	53.3	65.5	75.6	79.2	81.5	80.3	77.3	71.3	59.0	52.0	17
Pensacola, Fort Barrancas . .	53.6	55.6	61.8	68.5	75.4	80.8	82.3	81.6	78.5	70.1	61.0	55.6	18
Mobile, Arsenal at Mt. Vernon .	50.4	53.7	60.3	66.9	73.9	78.0	78.6	79.8	75.0	65.9	56.5	51.0	19
Mobile City	57.6	57.9	62.4	70.6	77.4	81.6	83.7	82.9	80.0	69.5	62.6	56.3	20
Erie, Ala.	45.4	51.4	58.9	62.9	73.9	78.2	80.5	80.5	75.3	64.8	53.2	47.2	21
Bay of St. Louis, &c., Miss. . .	..	..	..	..	..	81.0	82.9	82.6	79.1	..	..	..	22
Delta of Mississippi River . .	59.5	60.1	62.4	72.9	77.0	82.0	82.9	81.5	80.5	73.0	63.0	59.0	23
New Orleans	55.3	58.3	64.2	70.1	75.6	81.1	82.9	82.8	80.0	70.7	62.5	56.0	24
New Orleans	54.4	54.5	61.6	67.8	74.0	78.7	80.4	79.7	77.1	69.0	58.0	56.0	25
Fort Pike, near New Orleans .	54.7	56.8	62.3	70.5	77.0	82.2	83.4	82.9	79.2	70.5	62.8	55.8	26
Fort Wood, near New Orleans .	54.8	56.4	60.2	70.9	77.9	81.3	82.7	82.1	78.9	68.6	62.2	55.0	27
Baton Rouge, La.	53.5	55.0	61.9	69.3	75.6	80.5	81.8	81.3	77.1	67.6	59.9	54.2	28
Natchez, Miss.	49.1	51.8	59.1	67.1	72.0	79.9	80.2	79.5	76.2	69.1	55.1	48.6	29
Natchez, Miss.	52.3	54.5	59.7	69.8	74.5	80.8	81.3	80.9	77.2	67.0	57.0	49.7	30
Avoyelles, Red River, La. . .	52.0	52.0	59.0	67.0	72.0	79.0	80.0	80.0	75.0	66.0	56.0	51.0	31
Vicksburg	47.8	52.7	63.3	63.7	73.0	77.7	78.7	78.7	74.1	65.4	54.5	50.4	32
Natchitoches, La., Fort Jessup .	50.6	52.7	59.4	67.4	73.7	80.2	82.2	81.3	76.1	65.9	56.7	49.7	33
Fort Sabine, La.	51.6	43.8	59.1	70.3	68.5	79.1	79.5	78.4	72.4	71.4	64.6	53.8	34
Galveston, Texas	48.1	58.0	63.5	70.0	78.7	80.7	83.0	83.3	78.3	73.1	60.2	55.6	35
Corpus Christi, Texas . . .	56.3	57.0	66.6	69.8	77.9	82.0	82.5	83.1	81.0	73.4	64.9	56.9	36
Brownsville, Texas, and Matamoras	60.4	63.6	68.9	75.1	80.2	82.5	84.2	84.0	80.7	74.1	69.1	62.2	37
Ringgold Barracks, Texas . .	58.4	63.4	70.6	77.1	82.0	84.6	85.2	86.1	81.4	75.0	67.2	59.4	38
Laredo, Texas	55.6	60.8	69.0	76.7	81.9	83.9	86.3	87.5	82.6	74.2	64.7	55.6	39
Eagle Pass, Texas	52.1	57.3	65.1	73.4	79.7	82.8	84.7	86.0	82.2	72.6	61.8	52.3	40
Fort Clark, Texas	47.2	49.4	61.4	70.2	75.7	79.1	81.0	81.1	77.2	69.3	60.8	52.6	41
Fort Inge, Texas	49.5	55.4	62.6	68.0	75.4	79.4	81.5	82.6	78.7	68.5	59.2	51.4	42

TEMPERATURES—Continued.

	Spng.	Sum.	Aut.	Wint.	Year.	Yrs. and mos.	Date.	Position of Station. Lat.	Long.	Alt.	Authority.
	°	°	°	°	°			° ′	° ′	Ft.	
1	68.5	80.3	71.5	58.1	69.6	20	1824–1852	29.48	81.35	20	Mil. Post (Fort Marion).[6]
2	69.5	81.4	71.2	55.6	69.4	2	1854–1855	30.15	82.00	14	Baldwin, *Agl. Rep.*
3	70.6	80.6	70.2	57.2	69.6	6	1838–1843	29.34	81.48	25	Mil. Post.
4	71.8	79.1	72.4	63.2	71.6	3	1840–42; 1853	28.54	81.02	10	Mil. Post.
5	73.4	81.3	74.8	63.3	73.2	5–6	1840–41; 52–55	27.30	80.20	25	Mil. Post.
6	74.7	81.5	76.3	66.6	74.7	4–6	1839–41; 50–55	25.55	80.20	20	Mil. Post.
7	75.8	82.5	78.2	69.5	76.5	14	1831–38; 43–55	24.32	81.48	10	Mil. Post.
8	75.6	82.1	77.8	70.0	76.4	7	1830–1836	24.32	81.48	7	Whitehead, (S., 2, 10), *Am. Alm.*
9	75.4	82.4	77.0	65.3	75.0	4	1851–1854	26.38	81.00	50	Mil. Post.
10	72.1	80.2	73.1	62.3	71.9	25	1825–1854	28.00	82.28	20	Mil. Post. (Ex. 1833–36.)
11	71.9	79.3	73.8	60.9	71.5	3–8	May 1851–54	28.01	82.00	80	Mil. Post.
12	72.0	79.6	69.8	58.9	70.1	4–6	July 1838–42	29.30	82.28	60 ?	Mil. Post.
13	70.7	80.2	70.6	58.4	70.0	6	1832 *irreg.*–43	29.10	82.10	50	Mil. Post.
14	70.1	79.1	71.0	58.2	69.6	2–6	July 1840–42	29.07	83.03	35	Mil. Post.
15	71.3	80.8	72.2	57.7	70.5	5	1850 (ex. 53)–55	29.07	83.03	35	Steele, *MS.*, &c.
16	71.1	81.0	71.1	57.7	70.2	2–3	Oct. 1840–42	29.35	83.00	50	Mil. Post.
17	64.4	80.3	69.2	53.7	66.9	3	1835; 42–43	30.14	88.00	10	Mil. Post.
18	68.6	81.6	69.8	54.9	68.7	17	1822–29; 42–54	30.18	87.27	20	Mil. Post. (Irreg.)
19	67.0	78.8	65.8	51.7	65.8	14	1840–1854	31.12	88.02	200	Mil. Post.
20	70.1	82.7	71.0	57.3	70.3	4	1840–1843	30.42	87.59	25	North, *Am. Alm.*
21	65.2	79.7	64.4	51.3	65.2	3	1849–1851	32.40	88.00	200 ?	Jennings & Osborne, *MS.*
22	..	82.2	..	..	..	12	1833–35; 43–53	30.20	89.00	00	Summer Mil. Stations.
23	70.8	82.1	72.2	59.5	71.2	5	1831–1835	29.25	89.30	00	Forts St. Philip and Jackson.
24	70.0	82.3	70.7	56.5	69.9	20	1825–1853	29.57	90.00	10	Mil. Post.[7]
25	67.8	79.6	68.0	55.0	67.6	19	1833–1853	29.57	90.00	10	Barton, *Vit. Stat. of La., & Sanit. Rep.*
26	70.0	82.8	70.8	55.8	69.8	14	1825–1846	30.10	89.38	00	Mil. Post.
27	69.7	82.0	69.9	55.4	69.2	6–6	1832–35; 42–46	30.08	89.51	20	Mil. Post.
28	68.9	81.2	68.2	54.2	68.1	24	1832–1854	30.26	91.18	41	Mil. Post.
29	66.1	79.9	66.8	49.8	65.6	5	1799–1803	31.34	91.24	200	Dunbar, *Phil. Trans.*, 1809.
30	68.0	81.0	67.1	52.2	67.1	12	1836–1847	31.34	91.28	246	Tooley, *Drake's Miss. Valley.*
31	66.0	79.7	66.0	51.7	65.9	6	1833–1838	31.10	92.00	50 ?	Voorhies (mn., noon, night), *Barton's*
32	66.7	78.4	64.7	50.3	65.0	4	?	32.24	91.00	350	Hatch. [*Rep.*
33	66.8	81.3	66.2	51.0	66.3	23	1823–1845	31.33	93.32	100 ?	Mil. Post.
34	65.6	79.0	69.5	49.8	66.1	1	1837–1838	29.45	93.50	9	Mil. Post.
35	71.0	82.5	70.2	53.8	69.4	1–6	1851–1852	29.18	94.46	00	Coast Survey.
36	71.4	82.5	73.1	56.7	70.9	4	1846–49; 51–54	27.47	97.27	00	Mil. Post.[8]
37	74.7	83.6	74.6	62.1	73.7	7	1846–55 (ex.)	25.54	97.26	50	Mil. Post.
38	76.6	85.3	74.5	60.4	74.2	6	1849–1855	26.23	98.46	200 ?	Mil. Post.
39	75.8	85.9	73.8	57.3	73.2	6	1849–1855	27.31	99.30	400 ?	Mil. Post.
40	72.7	84.5	72.3	53.9	70.9	6	1849–1855	28.42	100.30	800 ?	Mil. Post.
41	69.1	80.4	69.0	49.7	67.0	3	1852–1855	29.17	100.30	900 ?	Mil. Post.
42	68.7	81.2	68.8	52.1	67.7	6	1849–1855	29.09	99.47	845	Mil. Post.

TABLE OF MEAN

STATIONS.	Jan.	Feb.	Mar.	Apl.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
	°	°	°	°	°	°	°	°	°	°	°	°	
Fort Ewell, Texas	52.9	57.6	67.0	74.0	78.4	82.7	84.4	83.8	80.6	72.4	64.8	56.9	1
Fort Merrill, Texas . . .	54.8	57.2	68.7	73.3	79.7	81.9	83.2	84.4	79.9	74.1	62.5	56.8	2
San Antonio, Texas . . .	53.3	57.5	63.2	69.4	76.4	80.5	82.0	83.9	79.8	72.2	61.8	50.9	3
Fort McKavett, Texas . . .	44.7	46.9	57.4	66.2	72.2	74.9	78.4	79.5	73.4	65.9	53.6	45.7	4
Fort M. Scott, Texas . . .	46.2	52.4	57.6	62.5	68.5	75.5	77.2	78.1	72.9	63.0	52.4	43.1	5
New Wied, Texas	50.1	51.0	64.0	71.3	78.2	81.9	84.1	84.7	80.0	70.3	61.1	50.1	6
Fort Croghan, Texas . . .	49.3	52.2	60.4	65.6	71.5	78.3	81.1	82.5	77.5	67.3	56.1	46.9	7
Austin, Texas	46.4	52.7	61.1	67.4	75.4	78.9	80.7	82.4	78.2	68.2	58.4	49.5	8
Fort Chadbourno, Texas . .	44.3	46.7	58.0	65.5	69.5	73.8	77.9	78.6	72.0	62.4	53.2	46.6	9
Fort Graham, Texas . . .	47.9	51.8	58.1	64.3	72.6	79.4	83.1	84.7	77.4	67.6	55.5	46.5	10
Clear Fork of Brazos River, Texas	42.9	49.3	58.0	66.4	71.9	76.4	80.7	81.5	74.4	63.6	53.2	46.3	11
Fort Worth, Texas	43.6	48.8	56.3	62.5	70.5	77.4	81.0	82.9	76.5	66.2	56.4	43.4	12
Fort Belknap, Texas . . .	42.8	47.5	56.9	65.8	72.0	78.0	82.3	82.5	77.3	66.8	51.3	44.7	13
Fort Arbuckle, Indian Territory .	39.1	43.7	53.2	61.8	69.9	76.3	81.7	82.1	74.5	62.7	49.3	39.5	14
Fort Towson, Indian Territory .	43.1	46.0	53.4	64 0	69.8	77.0	80.8	79.7	72.5	61.0	50.2	42.6	15
Fort Washita, Indian Territory .	42.9	47.0	53.3	63.2	70.0	76.2	80.7	80.9	74.8	63.3	51.6	42.4	16
Fort Smith, Arkansas . . .	40.2	43.9	51.6	62.4	69.9	75.5	79.2	78.1	72.2	59.6	48.3	39.3	17
Fort Gibson, Indian Territory .	40.1	42.4	52.9	61.0	69.1	76.8	80.7	80.2	73.5	61.5	49.9	40.8	18
Fort Atkinson, Plains . . .	33.4	35.2	44.6	53 2	64.8	73.0	79.2	80.9	70.7	57.0	36.2	27.5	19
Fort Scott, Kansas	32.9	35.0	43.1	55.7	65.5	72.1	77.2	75.5	68.6	55.3	41.9	31.1	20
Jefferson Barracks, Mo. . . .	32.6	35.1	45.1	57.1	66.3	74.1	78.0	76.4	68.1	55.7	43.1	33.8	21
St. Louis, Mo.	31.4	33.4	42.3	55.1	65.1	74.2	78.2	76.2	69.6	54.2	42·5	31.9	22
St. Louis, Mo.	32.9	35.0	44.4	58.3	66.4	74.0	78.5	76.5	68.7	55.4	40.9	33.6	23
Huntsville, Ala.	42.0	42.6	51.3	61.3	67.2	74.2	76.4	76.2	70.1	59.5	49.7	41.8	24
Nashville, Tenn.	38.2	40.8	49.4	61.9	68.3	76.5	79.5	75.8	70.8	55.3	45.1	39.6	25
Memphis, Tenn.	41.7	45.9	55.3	59.0	68.9	75.8	79.9	78.5	72.5	58.4	53.3	40.2	26
Glenwood, Tenn.	38.5	39.3	48.4	60.8	66.2	71.2	78.7	78.5	75.1	57.5	48.1	38.4	27
Lebanon University, Tenn. . .	33.7	38.5	47.3	53.9	66.4	73.2	76.4	74.1	68.0	57.0	46.9	35.2	28
Knoxville University, Tenn. .	30.5	42.8	52.4	50.4	64.7	68.5	74.1	69.9	66.5	59.6	44.1	44.5	29
New Harmony, Indiana . .	34.1	41.5	52.5	56.0	67.6	76.4	78.8	75.5	65.6	55.7	43.3	37.3	30
Louisville, Ky.	35.8	36.7	45.3	57.4	63.6	71.5	74.6	73.3	67.4	52.5	44.1	36.4	31
Highland, Illinois	..	..	..	..	..	..	..	..	..	..	..	..	32
Cincinnati, Ohio	30.0	34.4	43.9	57.6	61.3	71.2	74.5	73.3	68.3	55.1	41.7	34.5	33
Cincinnati, College, Ohio . .	33.1	34.1	43.5	54.1	63.6	71.4	76.5	74.2	66.0	53.2	42.5	33.8	34
Germantown, Ohio	28.8	32 2	40.2	50.9	61.9	69.4	74.1	71.4	65.9	51.3	40.5	30.7	35
Hillsborough, Ohio . . .	30.9	31.4	39.5	52 7	60.1	67.5	72.2	69.3	63.1	50.2	40.3	31.4	36
Portsmouth, Ohio	31.5	36.6	45.5	54.6	64.6	72.1	75.3	74.7	65.5	59.2	45.0	37.9	37
Marietta, Ohio	32.6	34.4	43.1	52.3	61.4	69.6	73.5	70.7	63.6	52.3	42.3	34.6	38
Steubenville, Ohio	29.7	30.0	38.7	52.1	61.1	68.8	73.9	70.5	63.0	59.9	38.8	30.8	39
Hudson, W. Res. College, Ohio .	28.1	29.3	37.8	51.5	58.1	67.8	72.9	69.8	61.5	48.0	35.6	29.0	40
Oberlin College, Ohio . . .	28.2	24.8	36.8	48.1	59.4	67.6	75.5	71.7	68.3	51.5	41.8	30.0	41
Milton, Indiana	29.5	28.8	38.2	52.8	62.7	69.2	77.5	73.6	69.5	53.6	41.0	30.8	42

TEMPERATURES—CONTINUED.

	Spng.	Sum.	Aut.	Wint.	Year.	Yrs. and mos.	Date.	Position of Station. Lat.	Long.	Alt.	Authority.
	°	°	°	°	°			° ′	° ′	Ft.	
1	71.4	82.5	73.1	56.7	70.9	2	1852–1854	28.05	98.57	200 ?	Mil. Post.
2	73.9	83.2	72.2	56.3	71.4	4	1851–1855	28.17	98.00	150 ?	Mil. Post.
3	69.7	82.1	71.3	53.9	69.3	3–6	1849–1852	29.25	98.25	635	Mil. Post.
4	65.3	77.6	64.3	45.8	63.2	3–6	1852–1855	30.55	100.05	2060	Mil. Post.
5	62.8	76.9	62.8	47.2	62.5	3	1849–1852	30.10	99.05	1300	Mil. Post.
6	71.2	83.5	70.8	50.4	69.0	2	1854–1855	29.42	98.15	800 ?	Ervendberg, *Agl. Rep.*
7	65.9	80.6	67.0	49.4	65.7	4–6	1849–1855	30.40	98.31	1000	Mil. Post.
8	68.0	80.7	68.3	49.0	66.7	3	1851–52; 54–55	30.20	97.46	200	Mil. Post, and Austin, *Agl. Rep.*
9	64.3	76.8	62.5	45.9	62.4	3	1852–1855	32.02	100.05	2120	Mil. Post.
10	65.0	82.4	66.8	48.7	65.7	3–6	1850–1853	31.56	97.26	800 ?	Mil. Post.
11	65.4	79.5	63.8	46.2	63.7	2–6	1851–1854	32.30	99.45	2300 ?	Mil. Post.
12	63.1	80.4	65.4	45.2	63.5	4	1849–1853	32.40	97.25	1100 ?	Mil. Post.
13	64.9	80.9	65.1	45.0	64.0	4	1851–1855	33.08	98.48	1600 ?	Mil. Post.
14	61.7	79.9	62.2	40.8	61.1	5	1850–1855	34.27	97.09	1000	Mil. Post.
15	62.4	79.1	61.3	43.9	61.7	20	1832–1854	34.00	95.33	300 ?	Mil. Post. (Ex. 1847–48.)
16	62.2	79.3	63.2	44.1	62.2	12	1843–1855	34.14	96.38	645	Mil. Post.
17	61.3	77.6	60.1	41.1	60.0	12	1842–1854	35.23	94.29	460	Mil. Post.
18	61.0	79.4	61.7	41.1	60.8	27–6	1827–1854	35.47	95.10	560	Mil. Post.
19	54.2	77.7	54.6	32.1	54.6	3	Nov. 1850–Sep. 53	37.47	100.14	2330	Mil. Post.
20	54.8	74.9	55.3	33.0	54.5	10	1843–1852	37.45	94.35	1000 ?	Mil. Post.
21	56.1	76.2	55.6	33.8	55.5	26	1827–1854	38.28	90.15	472	Mil. Post.
22	54.1	76.2	55.4	32.3	54.5	12	1843–1854	38.40	90.05	450	U. S. Arsenal.
23	56.4	76.3	55.0	33.8	55.4	23	1833–1855	38.37	90.16	450	Engelmann, *St. Louis Med. Jour.*
24	59.9	75.6	59.8	42.1	59.1	13	1829–1842	34.45	86.40	600 ?	Allen, *Drake.*
25	59.9	77.3	57.1	39.5	58.5	5	1840–1844	36.10	86.49	533	Hamilton, *Am. Alm.*, 1846.
26	61.1	78.1	61.4	42.6	60.8	3	1850–1852	35.08	88.00	400	Navy Yard.
27	58.5	76.1	60.2	38.7	58.4	2	1854–1855	36.28	87.13	481	Stewart, *Agl. Rep.*
28	55.9	74.6	57.3	35.9	55.9	3	1850–1852	36.20	86.20	680 ?	Stewart, *Agl. Rep.*, 1853.
29	55.8	70.8	56.7	39.3	55.7	1	1852	35.56	83.58	960	Morris, *Am. Jour. Sci.*
30	58.7	76.9	54.9	37.6	56.9	3	1826–1829	38.11	86.50	400	Troost, *Darby*, *Drake.*
31	55.4	73.1	54.7	36.3	54.9	9	Oct. 1841–Sep. 50	38.00	85.25	600 ?	Young, *Agl. Rep.*
32	56.9	77.9	56.8	34.1	56.4	12	1841–1852	38.40	89.45	600 ?	Ryhiner, *MS.*, *Agl. Rep.*
33	54.3	73.0	55.0	32.9	53.8	8	1806–1813	39.07	84.30	550	Mansfield, Drake (S., 2), *View of Cinn.*
34	53.7	74.0	53.9	33.7	53.8	20–2	1835–Feb. 55	39.06	84.29	543	Ray, *MS.* (corr. by N. Y. formula).
35	51.0	71.6	52.6	30.6	51.4	5	Dec. 1850–Dec. 55	39.30	84.10	720	Groneweg, *Clim. Montgom. Co., Ohio* [(6, 2, 10; 7, 2, 9).
36	50.8	69.7	51.2	31.2	50.7	15	1836–1850	39.15	83.30	1131	Matthews, (S., 2), *Agl. Rep.*, 1850.
37	54.8	74.2	55.0	36.0	55.0	20	1824–1846	38.45	82.56	540	Hempstead, *Drake.*
38	52.3	71.3	52.7	33.9	52.6	32	1818; 25–53	39.25	81.31	630	Hildreth, *Am. Jour. Sci.*
39	50.7	71.1	53.9	30.2	51.4	12	1833–1844	40.25	80.41	670	Marsh, *Drake* (6, 12, 6).
40	49.1	70.2	48.4	28.8	49.1	7	1838–1844	41.15	81.25	1131	Loomis, *N. Y. Met. Reps.* (9, 3).
41	46.6	70.2	51.2	29.2	49.3	5	1850–52; 54–55	41.23	82.10	799	Fairchild, *MS.* and *Agl. Rep.*
42	51.2	78.4	54.7	29.7	52.2	2	1854–1855	39.47	85.02	800	Kersey, *Agl. Rep.*

TABLE OF MEAN

STATIONS.	Jan.	Feb.	Mar.	Apl.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
	°	°	°	°	°	°	°	°	°	°	°	°	
Ann Arbor, Michigan . . .	23.6	21.0	32.7	48.7	59.0	65.8	73.0	70.9	65.0	51.1	37.9	25.3	1
Detroit, Micbigan	27.0	26.6	35.4	46.3	56.0	65.6	69.7	67.5	60.0	47.7	38.2	26.9	2
Battle Creek, Michigan . . .	24.1	22.6	33.7	49.3	58.5	68.6	76.2	72.3	67.5	51.3	39.9	27.0	3
Fort Gratiot, Michigan . . .	25.3	25.3	33.2	44.1	53.8	63.4	69.5	67.1	60.3	48.7	38.2	26.6	4
Penetanguishene, Canada . .	21.4	19.7	29.4	36.1	52.0	65.2	70.4	68.5	53.2	45.8	36.7	24.0	5
Temiscaming, Canada . . .	9.2	18.4	24.4	39.0	49.4	62.7	67.3	65.6	53.4	40.8	26.0	17.7	6
Mackinac, Mich.	19.4	17.6	25.7	37.0	47.5	57.3	64.5	64.1	55.1	45.2	34.3	23.1	7
Fort Brady, Mich.	17.2	16.2	25.1	38.3	49.3	58.4	64.7	62.9	54.6	43.5	32.5	21.5	8
Michipicoten, Lake Superior . .	10.6	16.6	26.1	34.7	51.9	55.0	57.0	60.0	49.7	44.9	29.0	22.4	9
Fort William, Thunder Bay . .	5.7	8.2	22 7	31.4	48.9	58.7	62.2	58.8	48.2	41.9	23.4	18.1	10
Fort Wilkins, Copper Harbor .	23.4	21.4	28.9	38.1	48.4	56.7	63.5	62.2	55.8	42.9	30.2	20.5	11
Fort Howard, Green Bay, Wisc. .	18.9	20.0	31.3	43.4	55.8	66.2	71.5	67.9	57.2	46.5	34.3	20.8	12
Fort Winnebago, Wisc. . . .	19.5	18.5	32.6	47.2	56.7	65.6	70.9	67.3	57.8	47.9	32.1	21.3	13
Milwaukie, Wisc.	25.2	29.4	34.8	40.7	51.3	64.8	69.8	67.5	61.2	50.7	38.5	23.5	14
Chicago, Illinois	23.6	24.7	32.3	46.1	56.3	62.7	70.8	68.5	60.1	48.5	37.9	29.3	15
Beloit, Wisc.	22.7	25.8	33.8	44.6	58.4	68.2	73.9	70.7	63.6	49.8	36.8	24.0	16
Kenosha, Wisc.	27.4	28.2	33.1	37.9	49.1	61.7	68.6	65.7	59.6	48.3	35.0	24.4	17
Emerald Grove, Wisc. . . .	21.8	26.8	33.5	40.6	54.8	66.0	71.3	68.3	60.2	48.9	33.3	20.4	18
Fort Armstrong, Rock Island, Ill.	22.8	24.7	37.8	51.1	62.7	71.4	76.5	74.5	63.9	52.3	39.0	27.1	19
Ottawa, Illinois	22.6	25.1	35.6	53.4	62.7	70.6	77.2	73 3	68.5	51.7	36.4	26.6	20
Augusta, Illinois	24.0	27.2	38.1	56.2	62.9	70.4	76.2	74.1	70.1	55.3	40.8	27.4	21
Athens, Illinois	25.7	28.5	39.6	57.9	65.6	71.8	79.4	77.4	73.0	56.0	42.5	29.8	22
Fort Madison, Iowa . . .	24.0	27.0	38.2	56.8	65.3	74.2	82.5	77.5	71.5	54.1	40.2	27.2	23
Muscatine, Iowa	20.2	25.5	34.8	46.4	57.9	66.4	70.5	68 9	62.5	48.8	35.4	22.6	24
Poulteney, Iowa	15.9	18.7	32.2	50.7	59.4	67.4	73.2	69.5	63.7	49.3	33.7	20.9	25
Dubuque, Iowa	19.8	23.3	35.1	53.8	62.3	69.1	75.2	72.0	66.3	52.5	38.7	24.5	26
Prairie du Chien, Wisc. . .	19.4	21.7	34.5	50.9	60.6	69.5	75.3	72.0	61.5	48.9	34.5	22.6	27
Fort Des Moines, Illinois . .	27.4	30.0	39.5	55.8	59.2	66.4	76.5	71.7	61.2	44.7	35.3	29.2	28
Fort Dodge, Illinois . . .	19.6	23.2	29.3	44.3	59.7	72.2	76.2	73.0	67.2	54.2	31.0	19.5	29
Fort Leavenworth, Kansas . .	28.0	31.1	42.2	55.5	63.6	71.3	76.7	74.2	66.2	54.4	40.4	29.8	30
Fort Riley, Kansas . . .	27.1	33.7	42.7	60.2	66.5	73.2	83.7	84.7	72.3	64.6	43.6	36.4	31
Council Bluffs, Nebraska . .	19.4	25.2	33.8	51.8	62.2	73.0	75.9	75.4	65.6	52 0	36.4	20.6	32
Fort Kearny, Nebraska . . .	21.1	26.1	34.5	47.2	58.8	68.5	73.5	72.3	64.4	49.6	34.1	21.9	33
Fort Laramie, Nebraska . .	31.0	32.6	36.8	47.6	56.1	67.3	74.7	73.8	64.2	50.9	35.8	28.0	34
Fort Snelling, Minnesota . .	13.7	17.6	31.4	46.3	59.0	68.4	73.4	70.1	58.9	47.1	31.7	16.9	35
Fort Ripley, Minnesota . . .	7.9	11.9	24.4	40.7	52.9	62.8	67.3	64.7	56.7	44.0	28.1	10.3	36
Sandy Lake, Minnesota . .	13.8	18.2	29.7	38.3	50.1	61.2	67.6	65.5	58.3	43.4	22.8	9.9	37
Fort Pierre	19.2	22.5	35.3	57.3	60.5	..	76.9	75.5	71.1	59.8	40.5	32.0	38
Fort Clark, Mandan Vill. . .	5.5	23.8	25.1	..	..	..	..	..	..	..	32.9	21.3	39
Fort Union, Missouri River . .	21.3	17.5	32.5	49.9	49.8	66.0	73.6	70.7	58.4	..	..	..	40
Fort Benton, Upper Missouri .	16.5	26.6	36.2	55.2	58.3	68.3	73.6	76.4	60.9	53.1	19.5	33.0	41
Pembina, Minnesota . . .	..	..	18.2	31.0	53.7	..	74.4	69.0	..	..	21.7	5.4	42

TEMPERATURES—Continued.

	Spng.	Sum.	Aut.	Wint.	Year.	Yrs. and mos.	Date.	POSITION OF STATION. Lat.	Long.	Alt.	AUTHORITY.
	°	°	°	°	°			° ′	° ′	Ft.	
1	46.8	69.9	51.3	23.3	47.8	2	1854–1855	42.15	83.30	700 ?	Woodruff, *Agl. Rep.*
2	45.9	67.6	48.7	26 8	47.2	13	1836–46; 49–51	42 20	82.58	580	Mil. Post.
3	45 4	71.2	51.1	26.6	47.8	5–6	1849–1855	42 20	85.15	800	Campbell, *MS.* and *Agl. Rep.*
4	43 7	66.7	49.1	25.7	46.3	17–6	1830–46; 49–52	42.55	82.23	598	Mil. Post.
5	39.2	68.0	45.2	21 7	43.5	1	May 1825–Apl. 26	44 48	80.40	626	Todd, *Richardson* (8, 8).
6	37.6	65.2	40.1	15.0	38.6	2	?	47.19	79.31	630	Siveright, *Richardson.*
7	36.7	62 0	43.8	20 0	40.6	24	1825–37; 32–54	45.51	84.51	728	Mil. Post.
8	37.6	62.0	43.5	18.3	40.4	31	1823–1854	46.30	84.33	600	Mil. Post. (Ex. 1849.)
9	37.6	57.3	41.2	16 6	38.2	?	1840–?	47.56	85.06	660	Keith, *Richardson.*
10	34.3	59.9	37.8	10 7	35.7	?	1840–?	48 23	89.22	660	*Richardson.*
11	38.5	60.8	43.0	21.8	41.0	2	Jun. 1844–Jun. 46	47.30	88.00	620	Mil. Post.
12	43.5	68.5	46.0	19.9	44.5	21	1822–40; 49–51	44.30	88.05	620	Mil. Post.
13	45.5	67.9	46.0	19.8	44 8	16	1829–1845	43 31	89.28	770 ?	Mil. Post.
14	42.3	67.3	50.1	26.0	46.4	8	–1852	43.04	87.57	600	Marsh, Lapham, *MS.*
15	44.9	67.3	48.8	25.9	46.7	5	1832–1836	41.52	87.35	591	Mil. Post.
16	45.6	70.9	50.1	24.2	47.7	6	1850–1855	42.30	89.04	750	Lathrop, *Wisc. Agl. Rep.*
17	40.1	65.3	47.6	26.7	44.9	3	1850–1852	42 35	87.50	613	Gridley, *Wisc. Agl. Rep.*
18	43.0	68.5	47.5	23.0	45.5	3	1850–1852	42.39	88.54	986	Densmore, *Wisc. Agl. Rep.*
19	50.5	74.1	51.7	24.9	50.3	11–6	1824–1835	41.30	90.40	528	Mil. Post,
20	50.6	73.7	52.2	24.8	50.3	2	1854–1855	41.20	88.47	620	Harris, *Agl. Rep.*
21	52 4	73.6	55.4	26.2	51.9	2	1854–1855	40.12	90.15	600 ?	Mead, *Agl. Rep.*
22	54.4	76.2	57.2	28.0	53.9	2	1854–1855	39.52	89.56	650	Hall, *Agl. Rep.*
23	53.4	78.1	55.3	26.1	53.2	2	1854–1855	40.37	91.28	550 ?	McCready, *Agl. Rep.*
24	46.4	68.6	48 9	22.8	46.7	8	1847–55 (ex. 53)	41.25	91.00	586	Parvin, *Am. Alm.*
25	47.4	70.0	48.9	18.5	46.2	2	1854–1855	42.40	91.21	800 ?	Odell, *Agl. Rep.*
26	50.4	72.1	52.5	22.5	49.4	2	1854–1855	42 29	90.50	680	Horr, *Agl. Rep.*
27	48.7	72.3	48.3	21.2	47.6	19	1822–25; 29–45	43 05	91.00	642	Mil. Post. (1823 excepted.)
28	51.5	71.5	47.1	28.9	49.7	2–2	1843–Feb. 1846	41.32	93.38	780	Mil. Post.
29	44.4	73.8	50.8	20.8	47.4	2	Aug. 51–May 53	42.28	94.03	944	Mil. Post.
30	53.8	74.1	53.7	29.6	52.8	25–6	1830–1855	39.21	94.44	896	Mil. Post.
31	56.5	77.2	60.2	32.4	56.6	1–6	Nov. 53–Jun. 55	39.03	96 25	1300	Mil. Post.
32	49.3	74.7	51.4	21.7	49.3	7	1820–25; 1843	41.30	95.48	1250	Mil. Post.
33	46.8	71 5	49.3	23 0	47.7	6–6	1849–1855	40.38	98 57	2360	Mil. Post.
34	46.8	71.9	50.3	31.1	50.1	6	1849–1855	42.12	104.47	4519	Mil. Post.
35	45.6	70.6	45.9	16.1	44 6	35–6	1819–1855	44.53	93.10	820	Mil. Post.
36	39.3	64.9	42.9	10.0	39.3	6	1849–1855	46.19	94.19	1130	Mil. Post.
37	39.4	64.8	41.5	14.0	39.9	2	1851–1852	46.55	93.00	1450	Holt, *MS.*
38	51.0	75.0	57.1	24.6	51.9	1	Jul. 1854–May 55	44.23	100.12	1660	Behman and Mil. Post, *MS.*
39	..	..	..	13.2	..	0–5	Nov. 33–Mar. 34	47.00	100.45	1800 ?	Pr. Maximilian.
40	44.1	70.1	..	..	..	0–9	1832–1833	48.00	104 00	2022	Pr. Maximilian.
41	49.9	72.8	44.5	25.4	48.2	1	Sep. 1853–Aug. 54	47.50	110 36	2663	Doty, *MS.*
42	34.3	71.7	..	..	..	0–7	1852–1853	49.00	97.00	700 ?	Cavileer, *MS.*

TABLE OF MEAN

STATIONS.	Jan.	Feb.	Mar.	Apl.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
	°	°	°	°	°	°	°	°	°	°	°	°	
Sitka, Russ. Amer.	30 0	30.7	34.1	39.9	46.0	52.5	55.1	55.1	50.0	44.1	37.7	35.9	1
Steilacoom, W. T.	38.7	40.6	42.9	48.9	55.8	60.6	64.2	63.8	57.7	52 3	45.0	39.3	2
Fort George, W. T.	36.1	42.4	44.8	48.6	53.8	59 6	61.4	62.7	59.6	56.1	47.6	39.6	3
Cantonment Stevens, W. T.	13.3	31.2	39.4	48 3	56.3	64.2	71.9	72.6	56.7	45.9	34.1	30.2	4
Lapwai (Kooskooskia), Oregon	31.8	38.8	42.7	52.8	57.5	68.9	70.1	72.0	64.0	48.1	41.5	40.4	5
Dalles of Columbia	33.1	40.0	46.4	53.0	59.6	67.1	73.2	70.8	61.7	53.6	41.3	33.7	6
Fort Hall, Oregon	24 3	24.1	25.2	42.7	..	..	..	63.4	59.6	48.0	34.7	22.5	7
Great Salt Lake, Utah	27.1	35 0	39.7	50.2	65.2	71 3	81.5	..	..	..	41.7	34.1	8
Oregon City	39.6	42.0	45.1	55.9	60.9	66.3	72.3	71.9	61.2	55.8	47.2	39.1	9
Fort Vancouver, W. T.	40.5	41.7	44.1	52.6	58.9	62.7	68.7	65.6	60.8	53.3	46.5	36.5	10
Astoria, Oregon	43.0	43.6	45.7	52.8	55.0	59.5	61.6	63.0	58.7	55.4	46.4	40.7	11
Fort Orford, Oregon	48.4	47.9	49.6	51.1	54.8	59.0	59.7	61.1	58.9	54.9	51.8	46.2	12
Fort Jones, California	31.4	37.4	43.1	49.3	54.7	61.5	71.5	68.7	62.7	51.8	41.8	32 5	13
Fort Humboldt, Cal.	43.1	46.8	50.0	54.1	55.3	58.6	56.7	57.0	57.0	53.0	48.6	45.7	14
Fort Ross, Cal.	47.2	48.0	49.9	51.3	55.3	56.9	57.9	58.4	56.0	53.4	50.9	48.9	15
Fort Reading, Cal.	44.2	49.3	54.4	59.4	65.8	77.9	82.9	79.1	71.8	62.3	52.9	44.8	16
Sacramento, Cal.	44 9	52.1	55.0	59.7	63.4	71.7	76.1	71.2	69.7	65.3	52.9	47.3	17
Sacramento, Cal.	45.3	48.4	51.3	59.2	67.0	71.7	73.9	73.0	66.9	64.9	52.0	45.1	18
Benicia, Cal.	47.0	52.1	53.1	57.4	59.2	67.1	67.3	66.6	64.6	62.8	54 3	47.9	19
San Francisco, Cal.	50.1	52 9	54.5	58.6	57.8	58.6	59.8	60 9	61.5	61.7	57.0	51.5	20
San Francisco, Cal.	49.6	51.8	52 9	55.3	55 3	56.8	57.9	57.2	58.3	57.9	54.3	51.2	21
Los Angeles, Cal.	52 8	55.1	58.3	..	..	73.1	75.0	75.0	75 0	69.0	59.0	60.8	22
Fort Miller, Cal.	47.0	53.0	56.7	62.9	68.8	83.2	90.2	83.0	76.1	67.5	55.5	48.0	23
Monterey, Cal.	52.2	50.5	51.5	53.7	56.8	57.8	58.5	59.6	59.3	58.4	54.2	50.9	24
Jurupa, Cal.	54.0	54.9	56.8	62.6	63.7	70 3	73.8	73.2	72.1	67.5	57.8	52.8	25
San Luis Rey, Cal.	52.0	50.7	54.3	..	..	..	70.6	73.7	73.5	65.5	58.5	50 6	26
San Diego, Cal.	51.9	53.3	56.0	61.2	62.7	67.4	72.7	73 7	70.9	65.5	56.9	51.7	27
Fort Yuma, Cal.	56.4	58.0	66.1	73.5	76.7	87.3	92.3	90.3	86.1	76.5	64.4	55.9	28
Honolulu, Sandwich Islands	71.7	72 1	72.0	74.1	76.2	77.7	78.9	79.1	78.1	76.3	74.1	73.9	29
Fort Defiance, New Mexico	26.2	30 8	38.3	46.6	51.0	64.0	69.9	67.0	56.2	46.2	35.7	29.3	30
Fort Massachusetts, N. M.	19.7	22 2	31.3	44.8	49.4	58.2	63.5	62.2	51.6	43.0	27.1	20.3	31
Fort Union, Las Vegas, N. M.	33.1	33.4	39.3	49.2	56.3	65.8	69.4	66.8	58.8	49.1	37 1	31.2	32
Santa Fé, N. M.	31.4	33.2	40.7	51.3	57.1	68.8	72.6	70.0	61.9	51.3	38.6	30.2	33
Laguna, N. M.	34.9	39.4	44.5	51.3	61.6	72.5	77.4	75.6	68.5	58.2	43.7	33.7	34
Albuquerque, N. M.	35.8	39.6	47.9	56 2	63.5	72 1	77.3	75.4	69.4	58.5	44.1	36.0	35
Fort Conrad; Valverde, N. M.	37.1	43.0	52.3	61.5	65.7	74 6	80.1	77.6	70 9	59.9	45.6	38.5	36
Fort Webster, N. M.	40.6	40 5	46 2	53.1	59.4	70.1	75.1	69 9	63.1	53 7	43 6	42.8	37
Ft. Thorn, Santa Barbara, N. M.	40.6	44.1	52.8	62.7	69.4	72 4	78 3	73.9	69.9	60 1	44.3	41.1	38
Fort Fillmore, N. M.	44.5	48.9	55 4	64 4	71.3	80.9	83.4	79.7	77.2	64.4	51.2	46.4	39
Mexico City	52.5	54.4	61.2	63.0	66 2	65.4	65.2	64.9	64.3	60.2	55.8	52 1	40
Vera Cruz	71.1	72 7	73.9	78.3	81.7	81.5	81.5	81.5	81.7	79.2	75 2	72.0	41

TEMPERATURES—Continued.

	Spng.	Sum.	Aut.	Wint.	Year.	Yrs. and mos.	Date.	Position of Station. Lat.	Long.	Alt.	Authority.
	°	°	°	°	°			° ′	° ′	Ft.	
1	40.0	54.2	43.9	32.2	42.6	7	1842–1848	57.03	135.18	50	Observ. Record, *Ann. Met. de Russ.;*
2	49.2	62 9	51.7	39.5	50.8	5–8	Nov. 1849–55	47.10	122.25	300 ?	Mil. Post. [and *Dove.*
3	49.1	61.2	54.4	39.4	51.0	2	1821–22; 23–24	46.18	123 00	100 ?	Scouler, *Edinb. Jour. Sci.* (6, 12, 6).
4	48.0	69.6	45.6	24.9	47.2	1	Oct. 1853–54	46.20	113.55	3412	Burr, *Stevens' Survey.*
5	51.0	70.3	51.2	36.9	52.4	2–6	1837; 40–Jun. 41	46.27	117.00	1000 ?	Spalding, *Wilkes's Exp. Expedition.*
6	53.0	70.3	52.2	35.6	52.8	3–4	Sep. 50–Jun. 55	45.36	120.55	350	Mil. Post. (Ex. Apr. 1851–Sep. 52.)
7	..	..	47.4	23.6	..	1	Aug. 49–Apl. 50	43.04	112.27	4500	Mil. Post.
8	51.7	75.9	..	32.1	..	3[10]	....	40.46	112.06	4351	Stansbury, Beckwith, Mil. Post.
9	54.0	70.2	54.7	40.2	54.8	3[11]	1849–1852	45.20	122 30	200 ?	Spalding, *MS.*
10	51.9	65.6	53.5	39.5	52.7	6	Dec. 49–Jun. 55	45.40	122.30	50	Mil. Post.
11	51.1	61.6	53.7	42.4	52 2	1–2	Aug. 50–Sep. 51	46.11	123.48	50	Mil. Post.
12	51.8	59.9	55.2	47.5	53.6	2	1852–53; 54–55	42.44	124 29	50	Mil. Post.
13	49.0	67.3	52.1	33.8	51.4	2–6	1853–Jun. 55	41.36	122.52	2570	Mil. Post.
14	53.1	57.4	52.9	45.2	52.1	1–6	1854–Jun. 55	40.46	124.09	50	Mil. Post.
15	52 2	57.7	53.1	48.0	52.8	4	1837–1840	38.35	123.00	50	Russian Station (reduced), *Dove.*
16	59.9	80.0	62 3	46.1	62.1	3–3	1852–1855	40.28	122 05	400	Mil. Post.
17	59.4	73.0	62.6	48.0	60.7	3	Apl. 53–Mar. 56	38.34	121.40	39	Logan, *Am. Alm.*
18	59.2	72.8	61.3	46.3	59.9	3	1849–1852	38.33	121.20	50	Mil. Post.
19	56 5	67.0	60.6	49 0	58.3	6[12]	1849–1855	38.03	122.08	64	Mil. Post.
20	57.0	60.1	60.1	51.5	57.2	3–2	Dec. 1850–54	37.48	122.20	50	Gibbons (S., 12); *Am. Jour. Sci.*
21	54.5	57.3	56 8	50 9	54.9	4	Jul. 52–Jun. 55	37.48	122.26	150	Mil. Post.
22	..	74.4	67.7	56.2	..	..	Jun. 47–Mar. 48	34 03	118.12	457	Mil. Post.
23	62.8	85.5	66.4	49.3	66.0	4	1851–1855	37.00	119.40	402	Mil. Post.
24	54.0	58.6	57.3	51.2	55.3	5[13]	1847–1852	36.36	121.52	140	Mil. Post.
25	61.0	72.4	65 8	53.9	63.3	3	Jul. 51–Mar. 54	34.00	117.25	1000 ?	Mil. Post.
26	..	..	65.8	51.1	..	1	Jul. 1850–51	33.13	117.25	20	Mil. Post.
27	60.0	71.2	64 4	52 3	62.0	6	1849–1855	32.42	117.14	150	Mil. Post.
28	72.1	90.0	75.7	56.8	73.6	3–6	Jun. 52–May 55	32.43	114.36	120	Mil. Post.[14]
											[10), *Dove.*
29	74.1	78.6	76.2	72.6	75.4	3–6	1821–22; 36–39	21.16	157.59	00	Rooke, *Voyage of the Venus,* (7, 2,
30	45.3	67.6	46.0	28.7	46.9	3	May 52–May 55	35.44	109.15	7200 ?	Mil. Post.
31	41.8	61.3	40 6	20.7	41.1	2–2	1852–1855	37.32	105.23	8365	Mil. Post.[15]
32	48.3	67.3	48.3	32.6	49.1	5–6	1850–May 51	35.54	104.57	6418	Mil. Post.
33	49.7	70.4	50.6	31.6	50.6	6	1849–Apl. 55	35.41	106.02	6846	Mil. Post.[16]
34	52.5	75.2	56.8	36.0	55.1	2–3	Dec. 49–Feb. 52	35.03	107.14	6000	Mil. Post.
35	55.9	74.9	57.3	37.1	56.3	4–6	1849–1855	35.06	106.38	5032	Mil. Post.
36	59.8	77.5	58.8	39.5	58.9	3–6	1851–1855	33.34	107.06	4576	Mil. Post.
37	52.9	71.7	53.5	41.3	54.8	2	1851–1852	32.48	108.05	6350	Mil. Post.
38	61.9	74.9	58.1	41 9	59.2	1–6	1854–Jun. 55	32.38	107.10	4500	Mil. Post.
39	63.7	81.3	64.3	46.6	64.0	4	1851–1855	32.13	106.42	3937	Mil. Post. [*Dove.*
40	63.4	65.2	60.1	53.0	60.4	1	1826	19.26	103.46	7469	Burkhardt (7, 3, 11), *Res. in Mex.,*
41	78.0	81.5	78.7	71.9	77.5	13	1791–1803	19.12	96 08	00	Orta, *Humb. N. Spain.*

STATIONS OF SHORT PERIODS, AND THE LESS IMPORTANT STATIONS OF THE NEW YORK AND MILITARY SYSTEMS.

STATION.	Lat	Lon.	Alt.	Yrs	Spg.	Sum	Aut.	Win.	Yr.	NOTES.
	° ′	° ′	*Ft.*		°	°	°	°	°	
Quebec	46.49	71.16	—	1	38 00	67 67	43.67	13.33	40.67	Gautier, 1743–44, *Acad. Roy. Sci.*, 1745.
Halifax, Nova Scotia . .	44.39	63 37	50?	9	43.04	62.17	42.75	23 80	42 95	Haliburton (?), 1820–28.*
Hampden, Me. . . .	44.43	68.48	100	1	41.77	64 39	43.72	17.17	41.76	Herrick. 1843–44, *Am. Alm.*
Carmel, Me.	44.47	69.00	175	2	39.39	65.94	45.92	15.17	41 61	Bell, 1854–55, *Agl. Rep.*
Concord, N. H. . . .	43 12	71 29	374	2	43.04	68.49	49.71	21.44	45.67	Prescott, 1854–55, *Agl. Rep.*
Exeter, N. H. . . .	42.58	70 55	?	2	41.44	65.27	48.59	21.42	44.18	Leonard, 1854–55, *Agl. Rep.*
Manchester, N. H. . .	42 59	71 28	300	2	44 79	70.44	50 80	23.64	47.42	S. N. Bell, 1854–55, *Agl. Rep.*
Burlington, Vt. . . .	44.29	73 11	367	6	41 43	67.47	45.27	19 33	43.37	Sanders, 1803–8; *Williams, Hist. Vt.*
Rutland, Vt.	43 38	72.57	—	1	41 00	66 30	45 00	22 17	43.62	Williams, 1789, *Hist. Vt.*
Brandon, Vt.	43.45	73.08	—	2	42.00	67.09	48.10	20.95	44.53	Buckland, 1854–55, *Agl. Rep.*
Windsor, Vt.	43.30	72.27	—	1	41.80	66.40	49.27	24 37	45.46	Fowler, 1806; *Thompson, Hist. Vt.*
Ipswich, Mass. . . .	42.41	70 46	—	3	47 48	69.48	51 35	32.34	50.16	(?) *Dove.*
Lowell, Mass. . . .	42.39	71.19	100?	7	44 80	70.97	51.62	27 21	49.21	Moor, 1846–52, *Am. Alm.* (S., 2).
Deerfield, Mass. . . .	42.33	72 38	—	2	42.10	66 22	46.57	20.60	43 87	Hitchcock, 1816–17, *Am. Jour. Sci.*
Watertown Arsenal, Mass. .	42.21	71.09	50	6	44.63	68.12	49.38	27.22	47.34	Mil. Post, 1837; 41–43.
Worcester, Mass. . . .	42.16	71.49	536	7	45 14	67.76	50.33	27.43	47 66	Smith, &c., 1839–43; 54–55: *Am Alm.*
Westfield, Mass. . . .	42 06	72.43	—	2	48.87	70.61	50.20	29.37	49.75	Davis, Nov. 1824–Oct. 26, *Am. Jour. Sci.*
Lenox, Mass. . . .	42.23	73 20	—	2	39.57	63 51	42.75	20.49	41.58	Metcalf, 1836–37.
Springfield, Mass. . .	42.06	72 35	199	2	45 44	70 43	51.72	24.49	48 02	Allin, 1854–55, *Agl. Rep.*
North Attleboro', Mass. .	41.52	71.23	175	5	43.71	69 10	49.40	24.67	46 72	Rice, 1851–55, *Alm.* and *Agl. Rep.*
Pomfret. Conn. . . .	41.52	72 00	1000	2	43.11	67.29	49.07	24.56	46 01	Hunt, 1854–55, *Agl. Rep.*
Litchfield, Conn. . . .	41.45	73 15	900?	1	38.18	65.77	48.68	26.07	44.68	Hendrick, 1850, *Reg. Rep.*
New Haven, Conn. . .	41.18	75.58	80?	2	47.54	69.78	52.51	33.44	50 82	Olmsted, 1827–28, *Am. Jour. Sci.*
Warren Centre, Conn. . .	41.45	73.18	900?	1	42.97	66.44	50.73	23.26	45 85	Hendrick, 1849, *Reg. Rep.*
Sharon, Conn. . . .	41.48	73.25	300?	18	..	..	..	..	48.10	Gov. Smith's *MS.*, 1816–33 (6, 12, 9).
Bloomfield, N. J. . . .	40.49	74.11	120	2	44.50	71.51	54.35	29.70	50.01	Cooke, *Agl. Rep.*, 1854–55.
Newark, N. J. . . .	40.45	74.10	50?	12	..	..	..	..	51.40	Whitehead, 1844–55 (daily extremes).
New York City . . .	40.45	73.59	80?	7	47.69	71.17	53.92	31.61	51.14	Morris, N. Y. Acad. Rep., 1846–55.
Mount Pleasant Acad., N. Y.	41.09	73.47	125	12	48.08	69.97	51.14	29.20	49.60	N. Y. Acad. Rep.
North Salem, N. Y. . .	41.26	73.38	361	19	46.48	68.89	49.79	27.25	48 10	(Do.)
Newburg, N. Y. . . .	41.29	74.05	150	18	47.76	70.32	52.00	28.21	49.57	(Do.)
Goshen, N. Y. . . .	41.20	74.11	425	11	46.72	67.02	49.00	26.66	47.35	(Do.) (Farmer's Hall.)
Montgomery, N. Y. . .	41.32	74.00	200?	13	47.84	69.55	50.40	27.14	48.66	(Do.)
Poughkeepsie, N. Y. . .	41.41	73.55	200?	16	48.75	71.39	52.41	27 69	50.06	(Do.)
Kingston, N. Y. . . .	41.55	74.02	188	19	47.99	71.15	51.26	28.17	49.64	(Do)
Redhook, N. Y. . . .	42.02	73.56	300?	12	47.65	69.18	50.53	26.10	48.36	(Do)
Hudson, N. Y. . . .	42.15	73.45	150	17	47.07	69.75	50.02	26 25	48.27	(Do.)
Lansingburg, N Y. . .	42 47	73 40	30	23	46.51	69.67	50.00	24.75	47.73	(Do)
Cambridge, N. Y. . . .	43.01	73.23	500?	14	44.05	66 60	47.20	24 13	45 50	(Do) (Washington Co)
Salem, N. Y.	43.15	73.30	800?	10	45.08	68.26	48.41	24.50	46.56	(Do.) (Washington Co.)
Granville, N. Y. . . .	44.20	73 17	900?	14	43.69	68.55	47.08	21.85	45.29	(Do)
Plattsburg, N. Y. . . .	44.42	73.26	180	5	42.38	67.87	48.47	22.98	45.42	(Do)
Plattsburg, N. Y. . . .	44.41	73 25	186	11	42 34	66.76	46.67	20.22	44.00	Military Post, 1839–52.
Malone, N. Y. . . .	44 50	74 23	703	3	43.16	64.19	44 98	21.31	43 41	N. Y. Acad. Rep.
Gouverneur, N. Y. . .	44 25	73.55	400	14	43.54	67.02	46.63	19.61	44.20	(Do.) and *Agl. Rep.*, 1855.
Belleville, N. Y. . . .	43 45	76.10	350?	9	45.77	66 80	48.93	24.19	46.92	(Do) (Union Lit. Soc.)
Lowville, N. Y. . . .	43 37	75.33	800	19	42 70	65 21	45.71	21.54	43.79	(Do.)
Johnstown, N. Y. . . .	43.00	74.23	688	14	43.41	67.32	46.41	22.33	44.87	(Do.)
Schenectady, N. Y. . .	42 48	73.55	250	3	44.26	67 42	48.02	23.62	45 83	(Do)
Bridgwater, N. Y. . .	42.55	75.17	1286	4	41.72	63 04	43.84	22.06	42.66	(Do.)
Hartwick, Cooperstown, N. Y.	42.38	75.01	1100	16	44.93	65.01	48.61	25.46	46 00	(Do.)
Delaware, N. Y. . . .	42.16	74 58	1384	2	43.52	68 42	46.30	28.41	46 66	(Do.)
Oxford, N. Y. . . .	42.28	75.32	961	17	43 87	65.85	46.08	23 12	44 73	(Do.)
Hamilton College, N. Y. .	42 49	75.34	1127	18	44.07	65.43	46.60	24.07	45.04	(Do)
Fairfield Academy, N. Y. .	43.05	74.55	1185	19	41.61	64 75	45.98	21.11	43.36	(Do.)
Oneida Institute, N. Y. .	43.08	75.14	475	7	43.10	67.31	46.72	21 50	44 66	(Do)
Oneida Seminary, N. Y. .	42.55	75.46	1249	18	42.33	64 34	46 75	22.31	43 98	(Do.)
Pompey Academy, N. Y. .	42.56	76 05	1300	17	41.11	64.00	44.10	21.84	42.76	(Do.)
Onondaga Academy, N. Y. .	42.59	76.06	500?	16	45 93	67.48	48 18	26 69	47 07	(Do.)
Utica, N. Y.	43.06	75.13	473	9	45.33	67.94	48.12	25.24	46 66	Aylesworth, 1839–47, *Reg. Rep.*
Wampsville, N. Y. . .	43 04	75.50	500	2	44.22	69.52	50.44	24.54	47.18	Spooner, *Agl. Rep.*, 1854–55.
Lodi, N. Y.	42.37	76.53	947	2	43.73	66.22	50.15	23.55	45 91	Lefferts, *Agl Rep.*, 1854–55.
Baldwinsville, N. Y. . .	43.04	76.41	500?	2	42 71	67.12	49.66	23 62	45 78	Bowman, *Agl. Rep.*, 1845–55.
Ellisburg, Union Acad., N. Y.	43.45	76.10	280	10	46.51	66.81	49.71	24.35	46 84	N. Y. Acad. Rep.
Mexico, N. Y. . . .	43.27	76.14	331	11	41.77	64.96	45.71	23.76	44.05	(Do.)
Cortland, Homer, N. Y. .	42.38	76.11	1096	18	42.75	64.33	46.49	24.33	44.48	(Do)

* These observations are given in Judge Haliburton's *Nova Scotia*, without note of authorship or mention of the hours. They appear to be from registered daily extremes, and to have been taken at Halifax. The means are computed only for the seasons, for the first six years.

STATIONS OF SHORT PERIODS—CONTINUED.

STATION.	Lat	Lon.	Alt.	Yrs.	Spg.	Sum.	Aut.	Win.	Yr.	NOTES.
	° ′	° ′	*Ft.*		°	°	°	°	°	
Ithaca, N. Y. . . .	42.27	76 30	417	17	46.37	68 12	49.35	28.62	48.12	N. Y. Acad. Rep.
Cayuga, N. Y. . . .	42.43	76.37	447	14	46.68	69.71	51.36	28.89	49.16	(Do.)
Prattsburg, Franklin Acad.	42.34	77.20	1494	10	43.96	64.64	46.23	25.63	45.11	(Do.)
Canandaigua, N. Y. . .	42 50	77.15	600	10	44.57	67.33	47.10	23.70	45.67	(Do.)
Monroe, N. Y. . . .	43.06	77.51	600	3	47.90	65.60	46.97	25.49	46.50	(Do.)
Gaines, N. Y. . . .	43.17	78.15	440	4	45.16	67.05	47.59	27.40	46.80	(Do.)
Milville, N. Y. . . .	43.08	78.20	500	8	44.17	66.40	47.96	27.12	46.41	(Do.)
Middleburg, N. Y. . .	42.49	78.10	800	18	45.21	66.52	48.12	27.24	46.77	(Do.)
Albion, N. Y. . . .	43.15	78.15	500?	4	49.15	70.05	52 87	33.00	51.27	McHarf, *Reg. Rep.*, 1845–48.
Lewiston, N. Y. . . .	43.09	79.10	280	18	45 95	68.51	50 20	27.96	48.16	N. Y. Acad. Rep.
Buffalo, N. Y. . . .	42 53	78 58	623	2	43.81	69 66	48.62	22.46	46.14	(Do.)
Niagara, N. Y. . . .	43 18	79.08	250	14	44.83	68.41	50 59	27.81	47.91	Military Post.
Oswego, Fort Ontario, N. Y.	43.20	76.40	250	9	43.70	66.92	50.39	24.73	46.44	(Do.)
Sackett's Harbor, N. Y. .	43.57	76 15	262	8	42.54	66.84	48.00	22.66	45.01	(Do)
Buffalo, N. Y. . . .	42 53	78.58	660	4½	42.73	66.93	47.92	27.42	46.25	(Do)
Springville, N. Y. . . .	42.30	78.50	1150?	8	43.11	64.44	47.11	26.32	45.25	Academy Reports.
Penn Yan, N. Y. . . .	42.43	77.10	740	18	43.29	67.52	48.17	26.75	46.43	Dr. Sartwell, *Reg. Rep.*
Cuba, Alleghany Co., N. Y.	42 40	78 00	1100	2⅓	39.89	63.12	43 75	21.46	42.06	Talcott, *Reg. Rep.* (10, 10).
Oaklands, N. Y. . . .	42.53	74 32	480	2	44.52	69.77	51.78	28.37	48 61	Delafield, 1849–50, *Tran. N. Y. Ag. Soc.*
Warren, Pa.	41.50	79.18	1200	1½	49.61	70.48	..	28 81	..	Penna. Syst., 1840–1, *Jr. Frank. Inst.**
Smethport, Pa. . . .	41.48	78.32	1500	3	44.00	65.60	45.20	24 80	44.90	(Do.) 1839–41.
Meadville, Pa. . . .	41.38	80.08	1050?	2	48.59	71 32	51.84	29.27	50.26	(Do.) 1839 irreg. 41.
Franklin, Pa. . . .	41.23	79.50	970	2	51.04	71.09	50 82	28.67	50.41	(Do.) 1840–41.
Butler, Pa.	40.52	79.55	900?	2½	50.38	71.86	51.77	29.69	50 92	(Do.) Aug. 1839–41.
Indiana, Pa.	40.40	79.10	1150?	2	53.74	71.83	51.98	30.44	52.00	(Do.) 1839–41 (imperfect).
Somerset, Pa. . . .	40 00	79.03	900?	2	47.02	67.29	47.41	28.53	47.56	(Do.) 1840–41.
Ebensburg, Pa. . . .	40.32	78.40	1500	2¼	42.92	68.81	45.53	24.95	46.80	(Do.) Oct. 1839–41.
Uniontown, Pa. . . .	39.54	79.42	900	1½	51.81	73.75	52.01	30.60	52.04	(Do.) 1839–41 (imperfect).
Bedford, Pa.	40.50	78 28	900?	2	51.85	73.84	52.15	31.61	52.37	(Do.) 1840–41.
Bellefonte, Pa. . . .	40.58	77.50	730	3	50.35	70.03	50.17	27.84	49.60	(Do.) 1839–41.
Huntingdon, Pa. . . .	40.30	78.01	670	2	50.52	73.44	51.67	29.55	51.30	(Do.) 1840–41.
Mifflintown, Pa. . . .	40.33	77.30	400	3	51.40	70.58	51.26	29 93	50.79	(Do.) 1839–41.
Northumberland, Pa. . .	40 52	76.52	400	3	51.04	71.09	50.82	28.67	50.41	(Do.) 1839–41.
Silver Lake, Pa. . . .	41.53	76.08	1200	3	47.46	69 24	49.80	22.11	47.15	(Do.) 1839–41.
Stroudsburg, Pa. . . .	41.00	75.20	150	2½	49.62	69.78	50.00	26.92	49.08	(Do.) 1839–41 (irregular).
Port Carbon, Pa. . . .	40.44	76.15	650	1½	46.71	71.14	49.10	28.32	48.82	(Do.) 1840–41.
Harrisburg, Pa. . . .	40.16	76.50	300	3½	49.55	69.56	50.07	28.66	49.46	(Do.) Jun. 40–41; 54–5; Heisely.
Morrisville, Pa. . . .	40.12	74.53	30	2½	49.27	71.25	53 97	29.77	51.07	1853–55, Hance, *Agl. Rep.*
Lima, Pa.	39 55	75.25	196	2½	49.60	72.20	53.79	30.29	51.46	1853–55, Edwards, *Agl. Rep.*
Middletown, N. J. . .	40 26	73.59	?	3	53.36	70.34	56.48	36 16	53.83	Jun. 1831–May 34, Jenkins, *Am. Jr. Sci.*
Burlington, N. J. . . .	40.00	75.12	26	2½	50.74	73.35	55.45	30.97	52.63	Frost, 1853–55, *Agl. Rep.*
Baltimore, Md. . . .	39 17	76.37	193	8	52.30	74.30	55.60	34.30	54.10	Edmondson, *MS.*, 1845–52.
Scuppernong, N. C. . .	33.50	76 30	30	2	58.60	74.70	60.00	43.30	59.10	Shepherd, 1852–53, *Agl. Rep.*
Camden, S. C. . . .	34.17	80.33	275	1	58.25	80.27	59.44	41.01	59.74	Holbrook, 1848, *Am. Alm.*
Columbia, S. C. . . .	34.00	81.00	100?	1	58.93	75.00	54.40	40.03	57.09	Webster, Feb. 1836–Jan. 37, *Reg. Rep.*
Charleston, S. C. . . .	32.45	79.57	—	3	66.03	79.90	67.66	51.15	66.18	Ryan, Dawson, 1840, 41, 44, *Am. Alm.*
Augusta, Ga.	33.28	81.54	300?	3	61.64	77.82	61.30	45.54	61.57	Holbrook, 1841–43, *Am. Alm.*
Sparta, Ga.	33.17	83.09	800?	2	63.90	79.20	68.20	46.50	64.45	Pendleton, 1852–53, *Agl. Rep.*
Fernandina, Fla. . . .	30.35	81.30	00	1	69.40	79.20	70.87	59.80	69.82	Mil. Post, 1820.
Knox Hill, Fla. . . .	30.30	86.00	100?	2	65.47	80.13	68.88	51.37	66.46	Newton, May 1853–Mar. 55, *Am. Alm.*
Eutaw, Ala.	32.46	88.04	200?	1¼	62.20	81.49	62.48	47.49	63.42	Winchell, 1850–51, *Reg. Rep. N. Y.*
Huntsville, Ala. . . .	34.36	86.57	600	1	60.67	80.33	65.33	48.67	63.75	Mil. Post, 1819; *Flint's Geog.*
Fort St. Philip, La. . .	29.25	89.30	00	1	70.06	82.89	72.89	54.08	70.00	1822 at Mil. Post.
Jackson, La.	30.51	91.09	80?	3	64.27	80.10	64.17	48.47	64.25	Carpenter, 1839–41, *Am. Jr. Sci.*, 1843.
Galveston	29.18	95.01	00	1	77.23	87.67	70.60	60.44	73.99	Berghaus, 1842; *Dove.*
Fort Houston	31.54	95.56	?	1	75.63	81.90	72.70	61.90	73.03	Berghaus, 1842; *Dove.*
Little Rock, Ark. . . .	34.40	92.12	150?	1	63.67	78.67	62.00	45.00	62.33	Goulding, 1840, *Am. Alm.*
St. Louis, Mo. . . .	38.37	90.15	450	1	60.00	79.83	63.33	40.00	60.79	Brown (12 m.), 1841, *Am. Alm.*
St. Louis, Mo. . . .	38.37	90.15	450	7	55.50	75.27	57.30	32.59	55.16	Assn. Nat. Sci., 1830–36; *Am. Jour. Sci.*
Newport, Ky.	39.05	84.29	500	7½	54.52	75.00	56.24	35.27	55.26	Mil. Post, 1847–1854.
Cincinnati, Ohio . . .	39.06	84.19	540	1	54.33	75.00	68.33	39.00	56.77	Mil. Post, 1819; *Flint's Geog.*
Cleveland, Ohio . . .	41.42	81.40	625	1½	46.40	67.00	51.40	30 80	48.90	Wade, 1852–53, *Agl. Rep.*
Chilicothe, Ohio . . .	39.20	82.45	650?	1	55.67	78.00	58.33	39.67	57.92	Mil. Post, 1819; *Hinton's U. S.*
Ann Arbor, Mich. . . .	42.16	83.30	750	3	45.50	66.30	48.40	25.30	46.40	"L. S. H.," 1851–53, *Agl. Rep.*
Jeffersonville, Ia. . . .	38.12	85.36	440?	1	57.00	80.33	61.00	42.67	60.23	Mil. Post, 1819; *Flint's Geog.*
Summit, Wisc. . . .	43.05	88.30	900	1	43.25	65.12	48.60	24.31	45.32	Spencer, 1851; *Wisc. Agl. Rep.*
Aztalan, Wisc. . . .	43.04	88.52	830	2	44.44	68.19	47.76	24.21	46.15	Brayton, 1851–52; *Wisc. Agl. Rep.*
Green Lake, Wisc. . .	43.48	88.56	800	2	42.58	68.18	48.97	24.38	46.03	Pomeroy, 1851–52; *Wisc. Agl. Rep.*
Baraboo, Wisc. . . .	43.29	89.14	800?	1	43.43	69.80	45.57	22.35	45.29	Mills, 1852; *Wisc. Agl. Rep.*
Fort Madison, Iowa . .	40.38	91.28	550?	4	50.50	73.20	53.10	26.30	50.80	McCready, 1850–53, *Agl. Rep.*
Lac-qui-parle, Min. . .	46.00	96.00	1200?	1	44.70	68.23	..	..	..	Riggs, 1853.

* A system of observation was established in Pennsylvania in 1839, supplying one academy, or some person at the county seat of each county, with instruments; and those in charge of these stations were to report under the direction of the Franklin Institute at Philadelphia. These journals were published in the *Journal of the Franklin Institute.* At some points, three complete years were observed, 1839 to 1841, but at most places they were quite irregular, and no full years were observed. The best results are embodied in this table.

MEAN TEMPERATURES IN NORTHWESTERN
THE TEMPERATE LATITUDES

STATIONS.	Jan.	Feb.	Mar.	Apl.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
	°	°	°	°	°	°	°	°	°	°	°	°	
BRITISH AND RUSSIAN AMERICA.													
Edmonton House, Saskatchawan R.	11.05	14.32	..	..	..	..	..	..	..	..	..	..	1
Carlton House, Sask'n R.	..	5.65	11.92	29.75	47.92	..	..	..	..	..	..	..	2
Cumberland House, Sask'n R.	—7.0	—4.6	15.2	31.0	51.3	58.8	61.8	59.5	45.8	35.0	17.2	5.6	3
Norway House	—7.0	—2.4	7.0	27.1	44.6	54.9	63.5	61.2	46.4	31.1	12.3	—1.7	4
Oxford House, Nelson R.	—22.1	—1.9	8.6	28.6	38.0	..	..	..	..	17.5	13.3	—23.1	5
York Factory, Hudsou's Bay	—5.1	—6.6	4.8	19.2	33.5	47.7	60.0	54.8	41.9	33.4	25.2	3.7	6
Rupert House, James's Bay	—4.1	—0.7	7.6	21.1	41.5	..	..	..	..	34.8	23.3	15.6	7
Fort Churchill, Hudson's Bay	—21.2	—7.3	—4.6	16.3	28.4	44.7	56.8	53.4	36.0	26.5	3.3	—14.0	8
Prince of Wales Ft., Hudson's Bay	—25.6	—17.5	—9.2	21.2	38.0	50.0	56.4	53.0	44.0	28.0	1.7	—15.5	9
Fort Hope, Repulse Bay	—29.3	—26.7	—28.1	—3.9	17.9	31.4	41.5	46.3	28.6	12.6	0.7	—19.3	10
Lake Athabasca	—23.0	+4.8	2.4	35.1	44.8	53.9	..	..	..	21.5	9.8	0.4	11
Fort Chepewyan, Lake Athabasca	—8.7	—4.0	3.1	19.8	45.4	55.0	63.0	58.1	43.5	33.0	19.1	2.8	12
Fort Reliance, Slave Lake	—25.0	—18.9	—6.1	8.2	36.0	..	..	..	..	20.7	13.4	—17.1	13
Fort Resolution, Slave Lako	0.4	—25.6	9.9	12.9	40.1	..	..	..	..	26.1	12.1	—2.6	14
Fort Enterprise	—15.6	—25.9	—13.5	5.8	31.2	..	..	..	31.6	21.7	—1.7	—30.5	15
Fort Confideuce, Great Bear Lake	—21.6	—21.5	—20.2	—4.7	..	..	..	..	..	19.4	—3.7	—38.7	16
Fort Franklin, Great Bear Lake	—23.3	—16.7	—5.4	12.4	35.2	48.0	52.1	50.6	41.0	22.5	—0.1	—10.9	17
Fort Simpson, Mackeuzie's River	—12.5	—9.1	5.5	26.3	48.2	63.6	61.0	53.8	49.1	24.3	8.5	—8.4	18
Pelly Banks, west of Rocky Mts.	—21.9	—14.7	—1.0	20.5	..	..	..	..	..	..	..	—14.0	19
Yukou, Yukon R., Russ. Amer.	—26.8	—26.4	—11.2	12.7	41.2	53.5	65.7	59.9	38.7	21.6	—8.3	—18.4	20
Sitka (New Archangel), R. A.	35.7	36.3	39.7	42.3	48.8	54.9	58.5	59.0	53.9	46.5	40.8	34.5	21
Iluluk, Alaska	34.5	31.5	32.0	35.3	41.2	46.8	50.9	56.7	45.9	37.2	34.1	30.2	22
TROPICAL AMERICA.													
Waioli, Hawaian Islands	67.2	68.4	69.5	70.2	74.6	76.4	76.3	77.2	76.8	74.0	72.3	69.7	23
Veta Grande, Mexico	49.0	51.2	57.6	60.2	63.4	63.5	60.1	59.5	58.6	58.5	55.4	52.0	24
Mexico City	..	..	..	65.5	65.7	66.1	62.6	60.4	61.5	57.9	56.7	..	25
Mexico City	..	..	..	..	..	..	..	..	..	..	..	..	26
Vera Cruz, Mexico	71.1	72.7	73.9	78.3	81.7	81.5	81.5	81.5	81.7	79.2	75.2	70.0	27
Vera Cruz, Mexico	74.4	73.0	74.3	76.7	81.5	80.7	79.5	80.2	80.0	77.0	74.5	71.5	28
Kingston, Jamaica	75.8	76.0	75.9	78.1	80.3	80.6	81.7	81.0	80.7	79.8	78.7	76.4	29
Havana, Cuba	65.4	70.0	72.1	75.4	79.7	83.7	85.2	83.6	80.6	73.3	72.6	69.9	30
Matanzas, Cuba	73.5	72.1	75.7	80.2	80.7	82.2	81.5	80.6	82.1	78.8	77.7	74.7	31
Ubajay, Cuba	64.4	67.1	66.9	70.0	76.4	82.0	83.5	83.1	79.5	75.9	69.1	62.1	32
Nassau, Bahamas	69.0	73.0	76.0	78.0	79.0	83.0	87.0	88.0	87.0	80.0	74.0	70.0	33
Bermuda	56.8	58.8	59.4	62.8	69.1	73.2	75.7	76.6	76.8	73.0	65.8	60.6	34
Pará, Brazil, S. America	80.0	78.9	78.9	79.3	80.6	81.1	81.6	81.5	81.1	81.2	81.9	81.5	35
Rio Janeiro, S. America	80.1	80.0	77.9	75.5	70.7	68.7	67.1	70.0	70.5	72.8	74.4	77.3	36
BRITISH ISLANDS.													
Penzance, S. W. England	42.6	44.9	45.3	48.1	54.5	59.5	62.1	61.1	57.1	53.4	47.5	45.2	37
Plymouth, S. W. England	44.6	44.8	45.6	48.5	54.9	58.9	62.0	61.8	57.8	52.7	48.1	45.1	38
Gosport, South England	39.0	41.4	44.9	49.9	55.6	61.0	64.0	63.1	59.3	53.7	47.3	42.5	39
Chiswick, near London	36.9	39.3	42.4	47.2	54.5	60.4	63.2	62.2	57.3	52.0	43.2	39.9	40
London, Roy. Soc. Record	37.2	40.1	42.5	46.9	53.5	58.7	62.4	62.1	57.5	50.7	44.0	40.4	41
Highland House Obser., near Lond.	36.3	38.5	42.3	47.4	55.8	58.7	61.7	58.9	56.6	50.0	42.9	39.2	42
Plaistow, near London	35.1	39.0	42.0	47.5	54.9	59.6	63.2	61.9	57.2	50.1	42.4	38.3	43
Greenwich Observatory	35.5	37.4	44.6	46.4	54.1	58.5	59.6	62.7	58.0	47.4	42.9	40.4	44
Oxford, Radcliffe Observatory	37.0	39.1	41.4	45.6	52.8	58.4	61.2	59.8	55.1	49.2	43.3	39.8	45
Tottenham	35.1	39.0	42.0	45.6	54.9	59.6	63.2	61.9	57.2	50.1	42.4	38.3	46
Cheltenham, near Gloucester	38.2	41.7	46.2	50.5	54.2	61.5	66.3	65.1	59.1	50.3	43.5	41.7	47
Swansea, South Wales	42.0	39.5	43.7	50.6	56.6	62.3	62.8	62.7	60.1	52.0	45.8	40.4	48
Bedford, Central England	38.1	41.6	45.3	49.9	58.1	61.1	64.3	62.6	58.0	53.4	45.3	41.8	49
Southwick, E. England	42.1	43.5	46.1	50.6	56.0	61.2	63.0	60.8	56.9	50.2	45.4	42.8	50
Lyndon, E. England	35.2	38.1	40.6	46.9	53.8	60.3	65.3	61.9	56.3	48.8	41.0	37.4	51
Boston, N. E. England	36.1	37.7	41.6	47.4	55.7	61.6	63.5	61.6	56.9	49.2	42.5	39.1	52
York, N. E. England	34.8	37.3	40.7	47.6	54.5	59.2	62.0	61.1	55.7	48.2	40.9	36.0	53
Manchester	36.7	39.3	41.8	47.1	53.2	58.2	60.8	60.4	56.3	50.0	42.9	39.0	54
Liverpool	38.7	40.8	42.0	45.2	51.3	55.7	58.6	58.5	54.6	48.9	43.9	41.9	55
Lancaster	36.4	37.2	39.4	43.2	50.3	54.4	56.0	55.5	53.1	46.2	39.5	36.2	56
Whitehaven, N. W. England	38.6	40.1	41.4	46.1	53.4	58.4	60.7	59.7	55.7	49.8	44.0	41.3	57
Carlisle, N. W. England	36.2	38.6	40.5	44.8	51.2	55.7	58.5	58.0	53.8	48.1	41.4	37.0	58
Lead Hills, South Scotland	32.0	34.8	37.5	42.9	49.6	55.1	57.2	54.9	50.4	44.1	37.5	33.3	59
Applegarthe Manse, near Dumfries	34.7	36.9	39.5	44.1	51.3	56.3	58.2	56.8	53.2	47.2	41.3	38.6	60
Glasgow	38.2	39.5	..	45.9	55.0	59.3	61.2	59.8	..	50.0	42.4	41.3	61
Glasgow	38.0	40.9	40.4	44.8	50.2	54.3	56.8	57.5	52.9	48.2	38.4	42.7	62
Edinburgh	37.4	38.2	40.5	44.2	50.3	56.0	58.7	56.8	53.4	48.8	41.4	39.7	63
Dunfermline, near Edinburgh	35.7	37.9	39.0	41.8	48.2	53.7	56.9	55.0	51.0	46.4	40.7	36.4	64
Aberdeen	36.9	37.8	40.6	44.7	52.3	56.7	58.8	58.0	54.6	48.6	42.1	39.6	65
Clunie Manse, noar Aberdeen	36.4	38.3	41.2	45.6	51.9	57.1	59.6	57.6	53.2	47.7	40.7	38.2	66
Kinfauns Castle, near Perth	36.8	38.4	40.8	44.8	50.6	56.7	58.4	57.9	53.6	46.5	41.8	38.3	67
Dublin, Ireland	35.5	40.9	42.5	47.0	52.0	57.3	60.7	60.7	55.8	50.0	43.1	40.1	68
Dublin, Ireland	39.2	40.7	43.2	48.0	54.4	60.2	61.5	61.4	56.5	50.1	43.7	42.0	69
Belfast, N. E. Ireland	39.0	40.0	43.1	44.4	54.6	59.1	60.7	59.8	54.2	49.5	42.7	41.8	70
Cork, S. Ireland	43.9	44.5	48.0	53.9	60.3	65.1	65.5	64.9	61.3	53.3	47.9	44.4	71

AND TROPICAL NORTH AMERICA, AND IN
OF EUROPE AND ASIA.

	Spng.	Sum.	Aut.	Wint.	Year.	Yrs. and mos.	Date.	POSITION OF STATION. Lat.	Long.	Alt.	AUTHORITY.
	°	°	°	°	°			° ′	° ′	Ft.	
1	..	..	..	..	..	0–2	1827	53.40	113.00	1800	Drummond, *Richardson.* (daily ex.)
2	29.86	..	..	..	..	0–4	?	52.51	106.13	1100	Richardson, *Jr. Boal Voy., &c.* (d. ex)
3	32.5	60.0	32.7	—2.0	30.8	1–10	Sep 1819–Aug 20	53.57	102.20	900 ?	*Richardson;* Aug. 39–May 40, Lewis,
4	26.2	59.9	29.9	—3.7	28.1	7	1841–1847	54.00	98.00	400	Ross, (d. ex.); *Reg. Rep.*, '52. [*Richd'n.*
5	25.1	..	..	—15.7	..	0–8	Oct. 1833–May 34	54.55	96.28	350 ?	*Richardson*, (corrected).
6	19.2	54.2	33.5	—2.7	26.1	1	Jun. 1830–May 31	57.00	92.26	20	Charles, *Richardson*, (corrected).
7	23.4	..	..	3.6	..	0–8	Oct 1839–May 40	51.21	78.40	20	*Richardson*, (corrected). [summer).
8	13.4	51.6	21.9	—14.2	18.2	1–3	Feb. 1838–May 39	59.02	93.10	20	Hardiug, *Richardson*, (19 obs. wint; 6
9	10.0	53.1	24.6	—20.9	16.7	1	1768–1769	59.00	93.10	..	Wales, *Phil. Trans.*, 1770.
10	—4.7	59.6	13.8	—25.0	6.1	1	"1846–1847"	62.32	86.56	0	Rae, *Richardson*, (8 times daily).
11	27.4	..	..	—5.9	..	0–9	Oct. 1843–Jun. 44	58.43	111.48	700	Richardson, &c. (hourly, Oct. to Feb.)
12	22.8	58.7	31.9	—3.3	27.5	3–6	1825–26; 38–39	58.43	111.48	700	Keith & Stewart, *Richardson.* (corr.)
13	12.7	..	..	—20.3	..	0–8	1834	62.46	109.00	650	Back, *Richardson*, (15 times).
14	21.0	..	..	—9.3	..	0–8	?	61.10	113.51	500	*Richardson*, (corrected).
15	7.8	55.0?	17.2	—24.0	13.9	3 ?	1820–1822	64.28	113.06	850	*Richardson.*
16	..	..	..	—27.3	..	0–7	Oct. 1848–Apl. 49	66.54	118.49	500	Richardson, (15 to 17 obs daily).
17	14.1	50.4	21.1	—17.0	17.2	2	....	65.12	123.13	500	Franklin, *Richardson*, (19 & 6 times).
18	26.7	59.5	27.3	—10.0	25.9	2–6	1837–1840	61.51	121.57	400	McPherson, *Richardson.* (corr.)
19	..	..	..	—16.9	..	0–5	?	61.30	130.00	1400	Campbell, *Richardson.* [in wint.")
20	14.3	59.7	17.4	—23.9	16.8	?	?	66.00	147.00	200 ?	*Richd'n*, ("6 obs. in sum. & ex. of day
21	44.5	57.5	47.0	36.5	46.4	10	1833–1842	57.03	135.18	50	Wrangell, &c. (9, 12, 3, 9), *Ann. Obs.*
22	36.2	51.5	39.1	32.1	39.7	1–9	Oct. 1827–Jun. 29	53.52	166.25	0	Lutke, (8, 1, 9); *Pogg, Ann.* [*Phys.*
23	71.4	76.6	74.4	68.4	72.7	1	Apr. 45–Mar. 46	22.15	160.00	0	Johnson, (5½, 1, 6½), *Sill. Jour.*, 1847.
24	60.4	61.0	57.5	50.7	57.4	2	1839–1840	22.50	102.25	8030	Burckhardt, (8½, 4½), *Res. in Mex., D.*
25	..	63.1	58.7	..	..	0–8	1769	19.26	103.46	7400	Alzate, *Humb. N. Spain.*
26	53.6	63.4	65.2	60.1	60.6	1	Aug. 1838–Jul. 39	19.26	103.46	6990 ?	Berard, *Dove;* (7, 3, 11).
27	78.0	81.5	78.7	71.3	79.8	13	1791–1803	19.12	96.09	50	Orta, *Humb. N. Spain.*
28	77.8	80.1	77.2	72.9	77.0	1	Juu. 1847–Jun. 48	19.12	96.08	13	*Army Met. Reg.*
29	78.1	81.1	79.7	76.1	78.7	5	1786–1790	17.58	76.47	50	Lindsay, (S., 2), *Edinb. Jour. Sci.*
30	75.7	84.2	75.5	68.4	75.9	8	1800–1807	23.09	82.22	50	Robredo, &c., *Sagra's His. Cuba; D.*
31	78.9	81.4	79.5	73.4	78.3	2	Aug 33–Jul 34; 35	23.02	81.38	50	Mallory, *Am. Jour. Sci.*
32	71.2	82.9	74.8	64.5	73.4	4	1796–1797	23.00	82.00	290	Robredo, *Humb. Pers. Nar.* (7, 12, 10).
33	77.7	86.0	80.3	70.7	78.7	?	?	25.16	77.48	0	*Martin's Brit. Colonies.*
34	63.7	75.2	71.9	58.8	67.4	1	Jul. 1836–Jun. 37	42.20	64.50	0	Emmet, *Edinb. Phil. Mag.*
35	79.6	81.4	81.4	80.1	80.7	4–6	Dec. 44–May 49	1.28 S.	48.29	20	Dewcy, *consul; Bond, MS.*
36	74.7	68.6	72.6	79.1	73.7	7	1782–1788	22.54	43.16	0	Dorta, (8 times daily); *Dove.*
37	49.3	60.9	52.7	44.2	51.8	21	1807–1827	50.08	5.30	0	Giddy, (reduced), *Phil. Mag.; Dove.*
38	49.7	60.9	52.9	44.8	52.1	5	1833–1837	50.22	4.06	0	Harris, (hourly), *Brit. Assn. Rep.*
39	50.1	62.7	53.4	41.0	51.8	16	1816–1831	50.47	1.07	0	Burney, (d. ex.), *Phil. Mag.; Dove.*
40	48.0	61.9	50.8	38.7	49.8	27	1826–1852	51.29	0.18	150 ?	Aunual Rep. (daily ex), *Dove.*
41	47.6	61.0	50.7	39.2	49.7	65	1774–81; 87–43	51.29	0.00	50	Corr. by Glaisher, *Phil. Trans.*, 1849.
42	48.5	59.8	49.8	38.0	49.0	42	1813–1854	51.30	..	100 ?	*N. Y. Reg. Rep.*, from *Times.*
43	48.1	61.6	49.9	37.5	49.3	24	1807–1830	51.30	0.02	150 ?	Howard, *Clim. of London.*
44	48.4	60.3	49.4	37.8	49.0	3	1849–1851	51.29	0.00	156	Glaisher, (bi-hrly.), *Mag. & Met. Obs.*
45	46.6	59.8	49.5	38.6	48.6	25	1828–1852	51.46	1.15	..	Radcliffe Observ., Vol. XV., 1855.
46	47.5	61.5	49.9	37.5	49.1	25	....	51.36	0.05	..	(Daily extremes); *Dove.*
47	50.3	64.3	51.0	40.5	51.5	3	....	51.54	2.04	150 ?	*Clark, Whitley*, (rcduced).
48	50.3	62.6	52.6	40.6	51.1	5	....	51.36	3.55	0	(Daily ex.), *Brit. Ass. Rep.*, 1848.
49	51.1	62.7	52.2	40.5	51.6	7	1828–1834	52.08	0.30	?	Smith, (d. ex.), *Lib. Usef. Know.*
50	50.9	61.7	50.8	42.8	51.5	11	1729–1739	52.30	1.25 E.	?	Lynn, *Phil. Trans.*, 1732–44; *Dove.*
51	47.1	61.9	48.7	36.9	48.7	28	1771–1798	52.32	0.03 E.	510	Barkcr, ycarly in *Phil. Trans.* (d. ex.)
52	48.4	62.2	49.5	37.6	49.4	25	1827–1852	52.48	0.05	?	(8½), *Phil. Mag.; Dove.*
53	47.6	60.8	48.3	36.0	48.2	25	1800–1824	53.57	1.05	100 ?	Ford, *Philip's Yorkshire; Dove.*
54	47.4	59.8	49.7	38.3	48.3	47	1794–1840	53.29	2.14	150	Dalton, &c. (8, 1, 11); *Dove.*
55	46.2	57.6	49.1	40.5	48.4	25	1768–1792	53.25	2.59	50	Hutchinson, (12 m.); *Dove.*
56	44.3	55.3	46.3	36.6	45.6	7	1784–1790	54.03	2.40	0	Campbell, (10 a. m.), *Manch. Mems.*
57	46.9	59.6	49.8	40.0	49.1	19	1834–1852	54.33	3.33	0	Miller, (d. ex.), *Jameson's, Ed. Jour.*
58	45.5	57.4	47.8	37.3	47.0	24	1801–1824	54.54	2.58	38	Pitt, (8, 1, 9; red.); *Dove.*
59	43.3	55.7	44.0	33.0	44.1	10	1811–1820	55.25	3.48	1280	Irving, (6, 1; red.); *Dove.*
60	45.9	57.1	47.2	36.7	46.7	24–6	1827–1851	55.13	3.12	170	Dunbar, (9, 9), *Ed. Phil. Jour.*
61	45.9?	60.1	49.0?	39.6	49.0?	9	1831–1840	55.51	4.14	00	(10 a. m.; red.)
62	45.1	56.2	46.5	40.6	47.1	2–4	1850–Oct. 52	55.51	4.14	?	*Ann. Rep.* (corr.); *Dove.*
63	45.0	57.1	47.9	38.4	47.1	16	1824–1839	55.57	3.11	220	Forbcs, (?) yearly to *Edin. Jour. Sci.*,
64	43.0	55.2	46.0	36.7	45.2	20	1805–1824	56.05	3.26	300 ?	Fergus, (9; rcd.); *Dove.* [*Dove.*
65	45.9	57.8	48.4	38.1	47.6	8	1823–1830	57.09	2.05	50 ?	Inncs, (8 a. m.); *Dove.*
66	46.2	58.1	47.2	37.6	47.3	16	1821–1836	57.12	2.35	50 ?	Macritchie, (10, 10), *Ed. Phil. Jour.*
67	45.4	57.7	47.3	37.8	47.0	24	1815–1838	56.23	3.19	150	Gordon, (8, 10, & d. ex.), *Ed. Phil. Jr.*,
68	47.2	59.6	53.0	38.8	49.7	17	1792–1808	53.20	6.11	50	*Trans. Irish Acad.; Dove.* [&c.
69	48.5	61.0	50.1	40.6	50.0	6	1836–1841	53.20	6.11	50	Apjohn, (d. ex.), *Portlock; Dove.*
70	47.4	59.8	48.8	40.3	49.0	6	....	53.40	7.36	50	*Whitley*, (9, 3; reduced).
71	54.1	65.1	54.2	44.3	54.4	10	....	52.00	9.00	..	*Whitley's Essay.*

MEAN TEMPERATURES IN

STATIONS.	Jan.	Feb.	Mar.	Apl.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
	°	°	°	°	°	°	°	°	°	°	°	°	
EUROPE AND ASIA.													
Stromness, Orkney Islands . .	38.0	38.9	40.8	42.3	48.3	53.0	55.4	54.9	52.3	48.6	42.4	41.1	1
Unst, Shetland Islands . . .	40.3	38.7	40.4	42.6	46.2	50.8	52.7	54.5	50.7	43.3	39.0	37.0	2
Thornshaven, Faroe Islands . .	37.5	36.9	39.7	41.8	45.4	53.4	55.9	54.5	51.5	45.9	41.7	42.6	3
Reykiavik, Iceland . . .	29 8	28.4	29.9	36.5	44.8	51.6	56.2	50.8	46.5	36.9	30.5	29.5	4
Archangel, Russia	6.6	9.2	21.9	31.4	41.7	55.2	60.8	57.6	47.6	35.2	22.6	12.5	5
Bergen, Norway	35.0	36.6	37.6	44.3	51.3	56.5	60.4	58.9	54.4	48.0	40.9	37.3	6
St. Petersburg, Russia . . .	15.7	17.5	24.4	35.6	47.7	58.2	62.7	60.8	51.0	40.6	29.4	21.2	7
Christiana, Norway . . .	21.3	22.1	29.3	38.8	50.4	58.1	61.2	59.7	52.1	41.5	32.4	25.1	8
Stockholm, Sweden . . .	24.3	26.6	29.6	36.7	48.2	57.0	63.4	60.8	53.6	44.2	35.3	27.1	9
Fellin, Livonia, Russia . . .	19.7	21.4	28.7	41.5	51.5	58.6	60.5	56.1	46.8	36.7	27.8	21.3	10
Mitau, (mouth of Dwina), Russia .	21.9	24.7	29.5	40.8	52.1	60.9	63.5	62.0	54.0	43.9	34.1	27.4	11
Riga, Russia (O. S.) . . .	24.6	26.7	33.5	45.9	56.3	61.6	65.8	61.5	51.6	40.5	31.5	24.4	12
Copenhagen, Denmark . . .	29.2	30.5	35.0	42.9	52.7	60.6	64.3	63.2	57.1	49.1	39.8	34.1	13
Konigsberg, Prussia . . .	24.4	26.9	31.5	41.4	52.0	57.4	62.6	61.7	53.6	43.7	35.8	27.1	14
Bremen, N. Germany . . .	29.8	33.8	38.8	46.3	55.6	61.9	64.7	62.6	57.5	50.3	39.4	35.1	15
Berlin, Prussia	27.7	31.6	38.1	47.4	56.5	63.3	65.8	64.4	58.4	49.9	39.3	34.9	16
Zwanenberg, Holland . . .	34.2	37.1	40.7	47.3	54.8	60.0	63.4	63.8	59.7	51.4	42.9	37.8	17
Amsterdam, Holland . . .	33.2	36.8	40.7	48.1	55.7	62.5	65.3	65.3	60.6	51.1	41.9	36.9	18
Warsaw, Poland	22.4	25.6	32.7	45.4	56.5	63.7	65.7	64.4	57.4	46.5	34.3	27.5	19
Brussels, Belgium	35.3	39.3	42.8	47.3	57.1	63.3	64.4	64.4	59.3	51.8	43.7	39.4	20
Manheim, Rhine	33.3	35.6	40.2	50.7	59.5	67.2	68.8	66.3	61.8	49.3	38.7	31.9	21
Paris, Franco	35.4	39.5	44.0	49.7	58.1	62.7	65.6	65.3	60.1	52.2	44.1	38.5	22
Strasburg, Rhine, E. France . .	31.0	35.0	41.9	49.7	58.2	62.6	65.8	65.1	58.7	50.0	41.1	35.7	23
Munich, Germany	29.6	33.0	41.2	46.9	57.6	62.1	64.7	64.1	58.1	49.2	39.0	34.9	24
Dijon, E. France	33.6	36.7	48.2	51.1	60.6	66.0	70.2	72.5	62.4	53.8	43.7	35.8	25
Geneva, Switzerland . . .	31.0	36.2	42.6	51.7	62.2	67.5	71.7	71.7	65.1	53.9	43.7	34.8	26
St. Bernard, Switzerland . .	14.4	18.2	21.8	27.3	36.0	40.7	44.3	44.1	38.8	31.1	23.8	19.5	27
Poitiers, Central France . .	34.9	39.6	48.0	52.0	57.9	64.4	69.3	69.8	62.6	53.8	45.3	39.9	28
Bordeaux, W. France . . .	41.0	45.0	51.3	56.1	60.8	66.9	73.1	73.2	67.1	58.1	48.4	43.2	29
Toulouse, S. France . . .	39.8	41.8	46.8	53.5	61.0	66.0	70.1	71.1	65.2	56.4	48.0	42.0	30
Marseilles, S. France . . .	43.2	45.4	48.4	56.1	63.2	71.0	75.9	71.9	68.7	58.7	50.2	47.1	31
Madrid, Spain	44.7	45.1	49.4	55.5	62.2	69.8	76.3	76.8	68.1	58.2	46.3	43.3	32
Lisbon, Portugal	52.5	53.6	56.3	59.0	63.6	69.4	72.1	71.2	69.4	62.6	55.4	51.4	33
Cadiz, Spain	51.4	53.7	55.2	59.6	63.7	68.1	70.2	72.8	70.2	67.1	58.8	53.6	34
St. Michael, Azores . . .	56.4	57.6	57.8	60.8	63.3	69.5	73.1	74.9	69.8	65.2	60.6	57.8	35
Funchal, Madeira	60.7	60.9	62.6	63.5	64.6	67.2	70.1	72.1	71.6	67.1	64 5	60.1	36
Santa Cruz, Teneriffe . . .	63.7	64.3	67.1	67.2	72.1	73.8	77.2	78.9	77.4	74.5	70.4	65.9	37
Oran, N. Africa	49.2	55.1	55.2	61.2	66.9	74.6	74.4	75.5	72.8	66.7	58.1	51.4	38
Algiers, N. Africa	52.9	54.8	56.0	59.1	66.3	71.5	75.2	76.5	73.2	68.5	61.9	55.1	39
Nicolosi, near Catania, Sicily .	50.4	50.1	57.0	59.4	69.1	72.8	80.8	82.1	73.5	64.9	58.4	53.2	40
Palermo, Sicily	51.4	51.3	54.0	58.6	64.8	71.2	75.7	76.3	72.6	67.0	59.1	54.7	41
Naples, Italy	46.2	47.6	51.2	56.7	64.8	70.8	76.1	76.3	69.3	61.9	53.1	49.1	42
Rome, Italy	45.0	47.3	51.7	57.8	65.3	71.1	76.0	75.6	70.1	64.8	53.4	47.8	43
Florence, Italy	41.2	44.6	50.6	59.6	65.4	71.2	76.9	75.9	69.1	60.4	50.3	45.5	44
Genoa, Italy	46.7	48.6	51.9	57.2	67.2	71.9	77.4	75.9	72.9	62.3	53.7	46.7	45
Milan, Italy	33.2	38.3	46.4	54.6	63.7	70.4	74.6	73.4	65.4	56.3	45 0	36.7	46
Venice, Italy	35.3	39.0	46.1	54.7	63.4	70.4	75.1	73.7	66.3	56.7	44.6	39.9	47
Vienna, Austria	29.3	33.5	40.8	51.8	62.1	67.5	70.7	70.0	61.9	51.2	40.3	33.0	48
Prague, Bohemia	28.5	32.0	38.6	49.0	57.1	65.1	68.0	67.8	60.2	50.1	39.5	33.0	49
Cracow, Poland	23.4	28.5	35.4	46.9	56.8	64.0	65.8	64 9	57.3	48.3	36.4	29.0	50
Moscow, Central Russia . . .	13.6	16.0	26.8	41.7	54.5	62.4	66.4	63.1	53.2	39.5	27.1	16.0	51
Catherinoslav, S. Russia . .	16.2	20.9	32.7	46.7	60.2	68.4	72.8	69.5	61.5	48.3	36.3	21.7	52
Odessa, S. Russia	25.2	27.6	33.1	46.4	57.6	66.2	73.3	70.8	59.7	52.3	40.0	29.4	53
Sebastopol, Crimea	34.3	36.5	42.4	50.9	61.5	70.1	71.1	70.5	63.4	53.8	44.1	37.0	54
Bucharest, Wallachia . . .	24.0	26.3	31.7	44.3	56.3	62.5	68.1	65.2	58.3	49.3	42.8	33.1	55
Constantinople, Turkey . . .	41.7	42.2	44.7	50.6	61.3	69.2	76.2	74.6	69.2	61.6	56.1	41.6	56
Smyrna, Turkey	43.6	52 3	53.0	53.0	65.6	73.5	..	..	68.3	62.7	54.6	43.8	57
Beyrout, Syria	53.9	58.2	61.3	65.3	71.3	75.4	81.9	82.1	79.6	76.8	65.7	56.7	58
Jerusalem, Syria	47.7	53.7	60.0	54.7?	66.8	71.7	77.3	72.6	72.2	68.4	58.9	47.4	59
Alexandria, Egypt	57.3	57.8	62.2	67.0	70.3	76.2	78.5	80.3	78.1	74.8	68.5	60.4	60
Mosul, Tigris River . . .	43.7	50.0	57.0	56.3	74.0	87.1	94.1	90.6	81.0	72.9	59.4	46.3	61
Erzeroum, Turkey	18.0	25.6	34.5	48.7	51.9	65.8	72.1	72.9	62.4	51.6	37.7	23.1	62
Trebizond, Black Sea . . .	45.2	48.9	47.3	48.8	61.0	69.2	74.7	75.2	70.5	63.9	58.9	46.4	63
Ooroomiah, Persia	27.5	32.6	37.2	47.1	55.9	64.0	70.3	72.7	64.4	54.2	41.5	34.7	64
Lenkoran, Caspian Sea, Persia .	38.2	40.2	47.1	55.2	64.7	73.3	76.5	77.7	68.9	61.5	50.3	42.8	65
Bakou, Caspian Sea, Russia . .	38.5	38.7	44.2	51.6	62.9	72.5	77.5	78.5	69.8	62.7	50.3	44.1	66
Teflis, Caucasus	32.5	37.6	44.3	54.2	64.5	69.0	75.4	76.1	66.5	57.1	44.1	37.7	67
Taganrog, Sea of Azof . . .	20.7	21.2	32.7	47.3	59.9	67.3	72.1	71.6	59.9	47.3	35.8	25.2	68
Astrachan, Caspian Sea . . .	21.3	21.3	33.5	50.5	73.2	74.1	78.2	76.4	68.2	50.5	39.6	28.9	69
Kasan, Russia (Volga) . . .	3.5	8.1	20.7	36.3	55.1	61.4	64.8	60.9	59.0	37.1	24.7	7.5	70
Veliki-Oustoug, Russia . . .	4.5	9.3	14.9	29.5	43.9	57.6	64.2	58.6	47.5	34.0	21.6	9.5	71
Catharinenberg, Ural . . .	4.1	8.2	18.5	34.4	48.5	59.5	64.4	58.1	47.1	33.6	18.8	2.9	72
Barnaul, Siberia	—5.6	4.3	9.2	33.3	50.7	61.7	67.5	60.3	47.5	35 6	13.5	0.3	73
Tomsk, Central Siberia . . .	—3.5	3.0	12.2	30.0	46.6	59.4	65.3	58.8	46.2	33.1	6.6	—1.1	74
Irkutzk, S. Siboria	—3.3	4.8	20.0	36.2	49.7	60.5	64.8	59.2	47.5	33.9	16.9	1.2	75
Jakutzk, E. Siberia	—43.1	—31.0	—9.8	16.9	37.4	55.6	62.6	57.0	39.6	15.4	—18.2	—35.9	76
Pekin, China	26.0	32.3	43.2	57.4	69.1	76.3	79.3	77.8	68.8	55.1	40.9	28.8	77
Nangasaki, Japan	43.4	44.0	50.4	61.0	69.0	77.1	80.2	83 2	78.0	66.5	53.2	47.2	78
Shanghai, China	40.5	41.0	48.6	57.0	65.0	72.0	83.5	83.5	73.0	64.5	58.0	42.0	79
Canton, China	52.5	55.0	62.5	70.0	77.0	81 0	83.0	82.0	80.0	73.3	65.2	57.1	80
Khatmandu, India	48.1	51.5	56.2	64.5	71.6	74.4	76.3	74.1	72.0	64.6	55.4	46.3	81
Ambala, Upper Indus, India . .	51.4	60.2	70.5	80.8	100.0	96.3	84.8	86.0	84.1	75.2	64.3	56.8	82

EUROPE AND ASIA—Continued.

	Spng.	Sum.	Aut.	Wint.	Year.	Yrs. and mos.	Dato.	POSITION OF STATION.			AUTHORITY.
								Lat.	Long.	Alt.	
	°	°	°	°	°			° ′	° ′	Ft.	
1	43.8	54.4	47.8	39.3	46.3	12	1827–1838	58.57	3.18	0	Clouston, (10, 10), *Dove.*
2	43.1	52.7	44.3	38.7	44.7	1	....	60.45	1.41	0	*Phil. Mag.* (7½, 8½).
3	42.3	54.6	46.4	39.0	45.6	3	?	62.06	6.46	0	*Dove.*
4	37.1	52.9	38.0	29.2	39.3	15	1823–1837	64.08	21.55	50	Tornstenson, *Dove.*
5	31.7	57.8	35.1	9.4	33.5	18	1814–1831	64.32	40.33 E.	0	Selvestrof, (7, 2, 9), *Kupffer; Dove.*
6	44.4	58.6	47.8	36.3	46.8	6	1828–1834	60.24	5.18	0	*Kaemtz, Dove.*
7	35.9	60.6	40.3	18.1	38.7	25	1822–1846	59.56	30.19	0	Napiersky, *Kupffer, Ann. Obs.*, 1848.
8	39.4	59.7	42.0	22.8	41.0	14	Apl. 37–Mar. 51	59.55	10.45	74	*Annl. Rep.; Dove.*
9	38.2	60.4	44.4	26.0	42.3	50	1808–22 (*in part*)	59.21	18.04	128	Ehreuheim, *Kaemtz*, (3 obs. daily.)
10	40.6	58.4	37.1	20.8	39.2	22	1824–1845	58.22	25.30	50	Dumpf, Neese, *Annales Obs.*, 1848.
11	40.8	62.1	44.0	24.7	42.9	25	1824–1848	56.39	23.44	100 ?	*Annales Obs.*, 1850.
12	45.2	63.0	41.2	25.2	43.7	35	1795–1832	56.57	24.07	50	Sand, Neese, *Ann. Obs.*, 1853.
13	43.5	62.7	48.7	31.3	46.6	63	1767–76; 82–1845	55.41	12.35	20	*Dove*, (corr.) [Ex. 1789–97, & 1825.]
14	41.6	60.6	44.4	26.2	43.2	24	....	54.42	20.30	68	Dove, (7, 2, 9).
15	46.9	63.1	49.1	32.9	48.0	11	1829–1839	53.04	8.49	50	Heinecken, *Dove.*
16	47.4	64.5	49.2	31.4	48.1	24	....	52.45	13.24	115	Dove, *Mems. Berlin Acad.*, (daily ex.)
17	47.6	62.4	51.3	36.4	49.4	92	1743–1835	52 23	4.46	0	*Dove.*
18	48.2	64.4	51.2	35.6	49.8	12	1775–1786	52.22	4.53	0	*Dove*, (corrected).
19	44.9	64.6	46.0	25.2	45.2	20	1827–1846	52.13	21.01	351	*Dove*, (6, 10, 4, 10).
20	49.1	64.0	51.6	38.0	50.7	10	....	50.51	4.22	270	Quetelet, (daily extremes).
21	50.1	67.4	50.0	33.6	50.3	8	....	49.29	8.30	270	*Dove*, (7, 2, 9). [*France.*
22	50.6	64.5	52.2	37.8	51.3	39	1806–1845	48.50	2.20	120	Obsy. record, *Ann. Meteorologique de*
23	49.9	64 5	50.0	34.2	49.7	32	1801–1832	48.35	7.45	500	*Ann. Met.; Dove.*
24	48.5	63.6	48.8	32.5	48.4	25	....	48.08	11.35	1690	*Dove.*
25	53.3	69.6	53.3	35.4	52.9	7	....	47.19	5.00	746	*Ann. Met.*
26	52.2	70.3	54.2	34.0	52.7	30	1818–1838	46.12	6.10	1280	Obsy. record, (S., 2); *Dove.*
27	28.4	43.0	31.1	17.4	30.0	21	....	45.50	6.06	8150	Hospice; *Dove.*
28	52.6	67.8	53.9	38.1	53.1	10	....	46.35	0.21	320	*Cotte, Dove.*
29	56.1	71.1	57.9	43.1	57.0	10	....	44.50	0.34 W.	50	*Cotte, Dove.*
30	53.8	69.1	56.5	41.2	55.2	11	....	43.36	1.26 E.	..	*Dove*, (9 obs. daily).
31	55.9	72.9	59.2	45.2	58.3	5	....	43.17	5.22	150	*Ann. Met.*
32	55.7	74.3	57.5	44.4	58.0	25	?	40.25	3.45 W.	2080	Ganiga, *Dove.*
33	59.6	70.9	62.5	52.5	61.4	5	....	38.42	9.08	300 ?	*Dove.*
34	59.5	70.4	65.3	52.9	62.0	2	Sep. 1810–Aug. 12	36.32	6.17	50 ?	Skirving, (reduced), *Dove.*
35	60.6	72.5	65.2	57.3	63.9	10	1840–1849	37.50	25.30	..	Hunt, *Proc. Brit. Assn.*, 1850.
36	63.6	69.9	67.7	60.8	65.5	5	1826–29; 34–35	32.38	16.56	50	Heinecken, *Mason's Cli. Mad.; Dove.*
37	68.8	76.6	74.1	64.6	71.0	2–4	1808–1810	28.27	16.26	..	Escolar, *Darby.*
38	61.1	74.8	65.8	51.9	63.4	2	1841–1842	35.50	0.40	50 ?	*Dove*, ("hours not given")
39	60.5	74.4	67.8	54.3	64.3	3–6	Apl. 1838–Oct. 41	36.47	3.43 E.	100 ?	Aime, (d. ex.), *Pogg. Ann.; Dove.*
40	61.8	78.6	65.6	51.2	64.3	6	....	37.35	15.06	2318	(Reduced), *Dove.*
41	59.1	74.4	66.4	52.5	63.1	39	1791–1829	38.07	13.22	0	Cacciatori, (cor. by Schouw), *Dove.*
42	57.5	74.4	61.4	47.6	60.3	13	1833–1846	40.52	14.15	456	Nobile, (S., 2), *Dove.*
43	57.2	74.2	62.7	46.7	60.5	20	?	41.54	12.25	170	(7, 2½, 9), *Dove.*
44	58.5	74.7	59.9	43.8	59.2	12	1821–1832	43.47	11.15	235	(7, 12, 11), *Dove.*
45	58.8	75.1	63.0	47.3	61.1	4	?	44.25	8.54	50	Schouw, *Dove.*
46	54.9	72.8	55.9	36.1	54.9	76	1763–1838	45.28	9.11	767	Cesaris, *Cli. of Lombardy*, (red), *Dove.*
47	54.8	73.1	55.8	38.1	55.4	7	....	45.26	12.11	20	(Reduced), *Dove.*
48	51.6	69.4	51.2	31.9	51.0	60	–1843	48.13	16.23	480	Jelinck, (8, 3, 10); *Dove.*
49	48.2	67.0	49.9	31.2	49.1	76	1771–1846	50.05	16.46	620	(Corrected), *Dove.*
50	46.4	64.9	47.3	27.0	46.4	27	1826–1852	50.04	19.51	648	(Corr.), *Ann. Obs. Phys. Rus.*, 1853.
51	41.0	64.0	39.9	15.2	40 0	21	1780–92; 1841–50	55.45	37.38	426	*Annales Obs.* (8, 2, 10), *Dove.*
52	46.5	70.3	48.7	19.6	46.3	10	1833–1842	48.20	35.06	250 ?	*Annales Obs.* (10, 10).
53	45.7	70.1	50.7	27.4	48.4	8	1840–1847	46.29	30.44	150 ?	(Reduced), *Dove*, 1852.
54	51.6	70.6	53.7	35.9	53.0	10	1827–1836 ?	44.36	33 32	150 ?	Zazybine, (daily ex.), *Dove.*
55	44.1	65.3	50.1	27.8	46.8	2	1841–1842	44.27	26.06	200	Koch, (7–8), *Dove.* [*Am. Jour. Sci.*
56	52.1	73.3	62.3	41.8	57.4	3–1	1840, Jun 41; 44–5	41.07	28.59	150	Dwight, (8, 2, 10), Hamlin, (S., 2, 9),
57	57.8	..	61.9	46.5	..	0–10	Sep. 1843–Jun. 44	38.26	27.07	50	Calhoun, (S., 2, 9).
58	65.9	79.8	74.0	56.3	69.0	2–5	Apl. 1842–45	33.47	35.26	50	(Missionaries), *Dove.*
59	60.5	73.9	66.5	49.6	62.6	1–1	May 43–May 44	31.47	35.14	2500	Lanneau, (S., 2, 9), *Dove.*
60	66.5	78.3	73.8	58.5	66.8	3	1847–1849	31.13	29.48	43	Thurburn, (d. ex.), *Jour. Geog. Soc.*
61	62.4	90.6	71.1	46.7	67.7	1–2	Jun. 1843–Jul. 44	36.19	43.10	300 ?	Laurie, (S., 2, sunset), *Dove.*
62	45.0	70.3	50.6	21.5	46.8	2–3	....	39.57	40.57	5225	(9, 4 ?), *Dove.*
63	52.4	73.0	64.4	46.8	59.1	2–6	1838–39; 43–44	41.01	39.45	100	Brant, Bliss; *Dove.*
64	46.7	69.0	53.4	31.6	50.2	2	Apl. 52–Mar. 54	37.28	45.00	7334	Stoddard, *Am. Jour. Sci*, 1855.
65	55.7	75.8	60.2	40.4	58.0	2	1848–1849	38.40	48.50	0	*Annales Obs. Russ.*, 1852–53.
66	52.9	76.2	60.9	40.4	57.6	2	1848–1849	40.21	49.32	0	*Annales Obs. Russ.*, 1852–53.
67	54.3	73.5	55.9	35.9	54.9	4	1850–1853	40.41	44.50	1500	Moritz, (hourly), *Annales Obs. Russ.*
68	46.6	70.2	47.8	22.3	46.8	16	1817–1832	47.12	38.57	80 ?	Manne, *Annales Obs.*, 1853.
69	52.4	76.2	52.8	23.8	51.3	2–5	Jnn. 1850–51; 53	46.21	48.05	70	(6, 2, 9), *Annales Obs. Russ.*, 1849–53.
70	36.2	62.4	36.9	6.3	35.5	10	1828–1837	55.48	49.07	160	Kupffer, *Annales Obs. Russ.*
71	29.4	60.1	34.4	7.8	32.9	13	1840–1853	60.45	46.19	400 ?	Ardacheff, *Annales Obs.*, 1853–54.
72	33.8	60.7	33.2	5.1	33.2	14	1836 (ex. 49)–50	56.50	60.34	820	(Hrly. after 1841), *Ann. Obs. Russ.; D.*
73	31.1	63.2	31.5	—0.3	31.4	6	1841–1846	53.20	81.37	400	*Annales Obs.*, *Dove.*
74	29.6	61.2	28.6	—0.5	29.7	5	....	56.30	85.10	300	*Dove.* [*Dove.*
75	35.3	61.5	32.8	0.9	32.6	10	1820–1830	52.17	104.17	1440	(7, 2, 9), *Bul. Acad. St. Petersburg;*
76	14.8	58.4	12.3	—36.7	12.2	15	Apl. 29–Mar. 44	62.01	129.44	150 ?	Neveroff, &c. (corrected), *Dove.*
77	56.6	77.8	54.9	29.0	52.6	11	1841–1851	39.54	116.26	97	Gatchkevitch, &c. (hrly.; bi-hr.) *Ann.*
78	60.1	80 2	65.9	44.9	62.8	4	1845–1848	32.45	129.52	26	Mohraicke, (9 a. m.), *Dove.* [*Obs.; D.*
79	56.9	79.7	65.2	41.2	60.7	1	Jul. 1844–Jun. 45	31.05	120.50	0	Fortune, (daily ex.), *Dove.*
80	69.8	82.0	72.8	54.9	69.9	10	1829–1838	23.08	113.16	0	*Am. Jour. Sci.*, 1840, (daily ex.)
81	64.1	74.9	64.0	48.6	62.9	2	....	27.42	87.46	4650	(7, 2, 9), *Dove.*
82	83.8	89.0	74.5	56.1	75.9	1	....	30.25	76.45	1000	(10, 10), *Dove.*

MEAN ANNUAL PRECIPITATION IN RAIN

[IN INCHES AND HUNDREDTHS OF

STATIONS.	Lat.	Alt.	Jan.	Feb.	Mar.	Apl.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	
	° ′	Ft.											
Fort Kent, Maine	47.15	575	3.73	2.60	1.77	1.06	2.63	1.36	7.72	2.57	1.36	4.41	1
Houlton (Hancock Bks.), Me.	46.07	620	2.86	1.91	1.84	2.83	2.95	3.82	4.83	2.27	2.94	3.92	2
Eastport (Fort Sullivan), Me.	44.54	70	3.17	3.18	3.16	2.80	2.92	2.15	4.28	3.62	3.17	3.29	3
Gardiner, Me.	44.12	..	3.40	2.80	3.10	3.30	4.20	3.60	3.10	3.60	2.80	4.10	4
Saco, Me.	43.31	69	3.69	3.26	3.72	2.12	5.52	2.69	3.57	4.76	2.76	4.34	5
Portland (Fort Preble), Me.	43.39	20	3.37	3.39	2.92	4.14	5.05	3.39	2.78	4.11	3.31	4.25	6
Portsmouth (Ft. Constitution), N. H.	43.04	20	2.42	2.64	2.16	3.44	3.43	3.01	2.40	3.80	2.43	3.29	7
Hanover (Dart. College), N. H.	43.45	400	2.90	2.70	3.00	3.10	3.80	3.90	3.50	4.00	3.00	4.10	8
Charlestown, Mass.[3]	42.24	60	2.66	2.22	4.08	3.20	3.33	2.36	2.88	3.42	3.03	3.52	9
Stow, Mass.	42.28	250 ?	2.50	2.78	3.98	3.52	4.05	2.68	3.84	3.20	3.13	4.06	10
Cambridge Observatory, Mass.	42.23	71	2.39	3.19	3.47	3.64	3.74	3.13	2.57	5.47	4.27	3.73	11
Worcester, Mass.	42.16	536	3.86	3.42	3.57	3.50	3.82	4.41	2.96	3.34	5.12	3.73	12
Watertown Arsenal, Mass.	42.21	50 ?	2.87	2.85	3.30	3.70	3.75	3.61	2.64	4.41	3.00	3.85	13
New Bedford, Mass.	41.42	50 ?	3.22	3.32	3.44	3.60	3.63	2.71	2.86	3.61	3.33	3.46	14
Nantucket, Mass.	41.17	30 ?	3.57	3.58	3.19	4.32	4.24	2.51	2.32	2.28	3.03	4.23	15
Providence (Brown Univ.), R. I.	41.49	75	2.80	2.81	3.26	3.66	3.53	2.85	2.95	3.86	2.88	3.48	16
Amherst College, Mass.	42.22	..	2.82	3.13	3.05	3.27	3.91	3.22	4.05	4.57	3.16	4.07	17
Williamstown, Mass.	42.43	800	1.81	2.13	2.95	2.49	3.34	4.46	4.10	3.30	3.20	1.45	18
East Hampton Academy, N. Y.	41.00	16	3.22	2.50	2.68	3.58	4.13	2.99	2.93	3.06	3.26	3.63	19
Jamaica, Clinton Hall Acad., N. Y.	40.41	30	2.50	2.23	2.83	3.05	3.54	3.69	3.94	4.09	3.38	3.48	20
Fort Hamilton, N. Y. Harbor	40.37	25	2.98	3.57	3.65	3.42	4.62	3.65	3.55	4.44	3.38	2.80	21
Fort Columbus, N. Y. Harbor	40.42	23	2.78	2.92	3.44	3.33	4.78	3.46	3.17	4.70	3.31	3.40	22
Flatbush, Erasmus Hall Ac., N. Y.	40.37	40	3.13	2.96	3.61	3.60	3.78	3.75	3.67	4.22	3.07	3.83	23
West Point, Military Academy	41.23	167	3.24	3.90	3.62	3.82	5.13	2.77	4.89	4.77	3.11	3.87	24
North Salem Acad., N. Y.	41.26	361	3.07	2.31	3.11	3.01	4.19	3.38	4.23	3.61	3.25	4.50	25
Newburg, Acad., N. Y.	41.09	150	2.73	2.09	2.26	2.00	4.09	3.52	3.17	3.00	3.19	3.61	26
Kingston, Acad., N. Y.	41.55	188	3.26	2.21	2.97	2.53	3.70	3.84	4.09	2.68	2.24	3.11	27
Kinderhook, Acad., N. Y.	42.22	125	2.21	1.53	2.48	2.97	3.41	4.55	4.35	3.35	2.94	3.25	28
Albany, Acad., N. Y.	42.31	130	2.77	2.62	2.82	3.12	3.85	4.48	4.39	3.44	3.34	3.69	29
Watervliet Arsenal, N. Y.[4]	42.43	30	2.67	2.08	2.19	2.92	3.55	3.73	3.51	3.10	3.24	3.00	30
Lansingburg Acad., N. Y.	42.47	30	2.29	2.07	2.16	2.40	2.78	3.92	3.55	2.52	3.02	3.19	31
Burlington University, Vt.	44.27	367	1.90	1.77	1.95	2.04	3.42	3.73	4.28	2.82	3.39	3.67	32
Plattsburg Barracks, N. Y.	44.41	186	1.38	1.20	2.18	2.55	3.63	3.51	3.22	3.30	3.72	3.67	33
Plattsburg, Acad., N. Y.	44.42	180 ?	3.05	3.28	4.63	2.81	2.35	3.74	2.53	2.81	3.31	4.53	34
Fayetteville, Vt.	42.58	600 ?	3.93	3.91	4.07	4.01	4.75	4.45	5.70	3.60	5.81	4.43	35
St. Martin's, near Montreal	45.31	118	2.84	1.84	2.69	6.26	2.59	8.35	1.26	2.27	4.82	6.90	36
Potsdam, St. Lawrence Acad.	44.40	394	1.40	1.06	1.48	1.70	3.02	3.31	4.03	2.81	3.11	3.34	37
Gouverneur Acad.	44.25	400	2.54	1.87	1.68	1.94	2.44	2.89	2.34	2.21	2.59	3.20	38
Lowville Acad.	43.47	800	2.34	2.38	1.78	1.90	2.79	3.42	3.67	2.84	2.82	3.28	39
Utica Acad.	43.06	473	2.92	2.61	2.75	3.17	3.34	4.60	4.53	3.70	3.55	2.78	40
Fairfield Acad.	43.05	1185	2.69	1.79	2.36	2.53	3.09	4.29	4.21	3.65	3.08	3.56	41
Cherry Valley Acad.	42.48	1335	3.13	2.62	3.00	3.09	3.67	4.56	4.41	3.19	3.92	3.64	42
Oneida, Conf. Seminary	42.55	1250	2.46	2.12	2.60	2.78	3.76	4.50	4.10	3.58	3.55	3.58	43
Oxford Acad.	42.28	961	2.64	1.98	2.25	2.66	3.41	4.08	4.03	3.62	3.25	3.44	44
Ithaca Acad.	42.27	417	1.82	1.64	2.15	1.84	3.22	3.43	3.35	2.64	3.32	2.56	45
Auburn Acad.	42.55	650	2.50	2.04	2.13	2.22	3.45	3.57	3.13	3.23	3.20	3.38	46
Penn Yan, N. Y.	42.41	600 ?	1.56	1.31	1.85	2.48	3.27	3.55	3.14	2.70	2.85	2.16	47
Rochester, University	43.07	506	1.88	1.40	1.81	1.97	3.04	3.25	3.01	2.60	3.05	3.39	48
Middlebury Acad.	42.49	800	1.46	1.77	2.26	2.46	2.92	3.40	3.30	2.81	2.83	2.88	49
Toronto Observatory, C. W.	43.39	341	1.70	1.09	1.61	2.57	2.98	3.04	3.72	2.81	4.46	2.96	50
Niagara, Fort	43.18	250	2.25	1.89	2.12	2.20	2.55	3.28	3.49	3.04	3.95	2.37	51
Fredonia Acad.	42.26	710	2.04	1.82	1.99	1.93	3.32	3.83	3.34	3.28	4.46	4.31	52
Newark, N. J.	40.45	80	..	..	..	..	..	..	..	..	..	..	53
Lambertville, N. J.	40.23	96	2.63	3.36	3.57	3.27	4.41	3.02	4.74	4.39	4.44	3.98	54
Pittsburg, Arsenal, Pa.	40.32	704	2.18	2.17	2.70	3.10	3.58	3.56	2.97	3.34	2.68	2.87	55
Carlisle Barracks, Pa.	40.12	500	1.67	2.41	2.92	2.75	3.38	2.68	4.69	2.30	2.27	2.62	56
Germantown, Pa.	40.03	100 ?	2.18	3.58	3.07	2.62	2.87	3.22	4 25	3.48	3.27	3.50	57
Gettysburg, Penna. College, Pa.	39.48	700 ?	3.03	2.40	3.18	3.22	3.34	3.11	3.39	3.70	3.12	3.31	58
Westchester, Pa.	39.55	150 ?	2.80	3.49	4.09	3.38	4.56	4.40	4.43	4.48	4.11	3.73	59
Philadelphia, Penna. Hospital	39.57	30	3.09	2.94	3.43	3.64	3.90	3.57	4.22	4.67	3.53	3.18	60
Frankford, Arsenal	40.01	30	3.07	2.51	2.61	3.60	3.30	4.49	3.78	5.14	3.25	2.59	61
Philadelphia, Hospital	39.57	30	3.12	3.24	4.02	2.11	3.68	3.20	3.55	5.18	3.22	3.06	62
Baltimore	39.18	90 ?	2.85	3.23	3.71	2.20	3.65	3.66	3.85	4.30	4.45	2.98	63
Baltimore, Fort McHenry	39.17	36	2.64	2.70	3.86	3.56	3.71	3.28	3.50	4.26	3.31	3.53	64
Washington, D. C.	38.53	78	4.45	2.75	2.57	4.03	3.85	2.93	3.92	3.67	3.52	3.55	65
Alexandria, Va.	38.49	50	2.55	3.83	1.77	3.43	3.39	3.89	3.35	3.84	3.02	3.13	66
Fort Washington, Md.	38.43	60	2.37	3.81	3.17	5.30	4.10	2.16	3.90	6.78	2.86	2.08	67
Williamsburg, Va.	37.15	100 ?	3.19	2.05	3.95	3.68	2.87	3.75	4.50	9.15	4.76	3.63	68
Norfolk, Fort Monroe, Va.	37.00	8	3.26	2.74	3.33	2.80	3.64	3.78	5.56	5.70	3.93	2.82	69
Camden, S. C.	34.15	275	..	..	..	..	..	..	..	..	..	..	70
Charleston, S. C.	32.46	30	2.33	3.39	3.02	1.72	3.66	5.00	6.15	7.53	6.34	3.04	71

AND MELTED SNOW IN THE UNITED STATES.

VERTICAL DEPTH OF WATER FALLEN.]

	Nov.	Dec.	Spng.	Sum.	Aut.	Wint.	Year.	Yrs.	Date.	AUTHORITY.
1	3.86	3.36	5.46	11.65	9.64	9.71	36.46	1	Sep. 1844–Aug. 45	Surgeon of Military Post.[1]
2	3.29	2.71	7.62	11.92	9.95	7.48	36.97	9–3	Jun. 1836–Aug. 45	(Do.)
3	3.39	4.26	8.88	10.05	9.85	10.61	39.39	8–6	1841–45; 49–53	(Do.)
4	3.60	3.90	10.60	10.30	10.50	10.10	41.50	16	1837–1852	Gardiner, *MS.*
5	3.81	4.87	11.36	11.02	10.91	11.82	45.11	8	1843–1851	Batchelder & Garland, *Am. Alm.*
6	4.37	4.17	12.11	10.28	11.93	10.93	45.25	8–6	1840–45; 49–53	Surgeon Mil. Post.
7	3.23	3.32	9.03	9.21	8.95	8.38	35.57	13	1836–45; 49–53	(Do.)
8	3.40	3.60	9.90	11.40	10.50	9.10	41.00	18	1835–1852	Young.
9	2.86	2.27	10.61	8.66	9.41	7.15	35.83	11	1792–1802	Barrett, *Mems. Am. Acad.*
10	2.33	3.03	11.55	9.72	9.52	8.31	39.10	10	1795–1804	Newell, *Mems. Am. Acad.*
11	4.57	4.31	10.85	11.17	12.57	9.89	44.48	12	1841–1854	Bond, *Am. Alm.*
12	4.56	4.57	10.89	10.71	13.51	11.85	46.96	13	1842–1854	State Insane Hosp., Smith, &c., *Am. Alm*
13	3.98	4.11	10.75	10.66	10.83	9.83	42.07	7	1836–1844	Surgeon Mil. Post.
14	3.97	3.74	10.67	9.18	10.76	10.42	41.03	42–9	1814–Jun. 1856	Rodman, *MS.*
15	3.86	4.51	11.74	7.61	11.12	11.66	42.13	8	1848–1855	Mitchell, *MS.*
16	4.14	3.83	10.45	9.66	10.50	9.44	40.05	23	1832–1854	Caswell, *Am. Alm.*
17	4.16	3.75	10.23	11.84	11.39	9.70	43.16	18	1837–1854	Snell, *Alm. & MS.*
18	2.20	1.47	8.78	11.86	6.85	5.41	32.90	4	1816–1819	Dewey, *Mems. Am. Acad.*
19	3.63	3.07	10.39	8.98	10.52	8.79	38.60	16	1827–1842	Dayton, &c., N. Y. University System.[3]
20	3.49	2.85	9.42	11.72	10.35	7.58	39.07	25	1826–1850	Acad. Principals, N. Y. Univ. System.
21	3.75	3.84	11.69	11.64	9.93	10.39	43.65	14	1839–1854	Surgeon Mil. Post. (Ex. 1841, 42.)
22	3.59	3.93	11.55	11.33	10.30	9.63	42.23	19	1836–1854	(Do.)
23	3.69	3.68	10.99	11.64	10.59	9.77	43.00	26	1826–1851	N. Y. Univ. System.
24	3.76	3.65	12.57	12.43	10.74	10.79	46.53	12	1843–1854	Mil. Post.
25	3.10	3.30	10.30	11.22	10.85	86.8	41.05	18	1830–1850	N. Y. Univ. Syst. (Ex. 1836, 37, 39.)
26	3.11	2.25	8.35	9.69	9.90	7.07	35.02	18	1828–1849	(Do.) (Ex. 1831, 37, 41, 45.)
27	3.46	3.34	9.20	10.61	8.81	8.81	37.43	19	1829–1849	(Do.) (Ex. 1843, 44.)
28	2.69	2.75	8.86	12.25	8.84	6.49	36.44	17	1830–1846	(Do.)
29	3.24	2.91	9.79	12.31	10.27	8.30	40.67	27	1826–1852	(Do.) Beck, Cooke.
30	2.93	2.33	8.66	10.34	9.17	6.38	34.55	18	1836 (ex. 44)–1854	Mil. Post.
31	2.82	2.59	7.34	10.00	9.03	6.95	33.32	20	1826 (ex. 38)–1846	N. Y. Univ. Syst.
32	2.76	2.35	7.41	10.83	9.82	6.02	34.11	20	1838–1852	Thompson, *Hist. Vt.*[5]
33	2.66	2.37	8.36	10.03	10.05	4.95	33.39	10	1840–1852	Mil. Post.[6]
34	2.43	2.63	9.79	9.08	10.27	8.96	38.10	3	1847–1849	N. Y. Univ. Syst.
35	5.83	3.55	12.78	13.75	16.07	11.39	53.99	6	Jan. 1827–May 33	Field, *Am. Jour. Sci.*
36	4.88	2.58	11.54	11.88	16.60	7.26	47.28	2	1854–1855	Smallwood, *Can. Jour. Sci.*
37	1.93	1.44	6.20	10.15	8.38	3.90	28.63	20	1828 (ex. 47)–1848	N. Y. Univ. Syst.
38	2.16	1.67	6.06	7.44	7.95	6.08	27.53	9	1833–35; 38–45	(Do.)
39	2.94	2.22	6.47	9.93	9.04	6.94	32.38	18	1827–1848	(Do.) (Ex. 1834, 36, 37, 38.)
40	3.43	3.19	9.26	12.83	9.76	8.72	40.57	19	1826–1846	(Do.) (Ex. 1837, 38.)
41	2.46	2.74	7.98	12.15	9.10	7.22	36.45	17	1828; 1831–49	(Do.)
42	3.17	2.73	9.76	12.16	10.73	8.48	41.13	11	1827–36; 41–45	(Do.)
43	3.00	2.77	9.14	12.18	10.13	7.35	38.80	19	1830–1849	(Do.)
44	2.45	2.25	8.32	11.73	9.14	6.87	36.06	17	1829–1845	(Do.)
45	2.86	1.96	7.21	9.42	8.74	5.42	30.79	13	1828–1848	(Do.)[7]
46	2.85	2.72	7.80	9.93	9.43	7.26	34.42	22	1827–1849	(Do.)
47	1.86	1.45	7.60	9.39	6.87	4.32	28.18	16	1829–1844	Sartwell, *Regents' Reports.*
48	2.94	2.10	6.82	8.86	9.38	5.38	30.44	19	1830; 1834–51	Dewey, N. Y. Univ. Syst.
49	2.56	1.79	7.64	9.51	8.27	5.02	30.44	17	1826–1848	(Do.)
50	2.91	1.50	7.16	9.57	10.33	4.29	31.35	16	1840–1855	Lefroy & Cherriman, *Mag. & Met. Obs.*
51	2.36	2.27	6.87	9.81	8.68	6.41	31.77	5–6	1849–1854	Mil. Post.
52	3.27	2.96	7.24	10.45	12.04	6.82	36.55	16	1830–1848	N. Y. Univ. Syst.
53	3.57	..	..	..	10.81	..	44.51	17	1844–1855	Whitehead, *Newark Adv.*
54	3.17	3.68	11.25	12.15	11.59	9.67	44.09	18	1838–1855	Parsons, *Am. Alm.*[8]
55	2.68	3.13	9.38	9.87	8.23	7.48	34.96	18	1837–1854	Mil. Post.
56	2.79	3.53	9.05	9.67	7.68	7.61	34.01	6	1848–1853	Mil. Post.
57	3.01	3.05	8.56	10.95	9.78	8.81	38.10	8–6	July 1819–1827	Haines, *Darby's U. S.*
58	3.34	3.67	9.74	10.20	9.77	9.10	38.81	17	1839–1855	Jacobs, *MS.*
59	3.62	3.85	12.03	13.31	11.46	10.14	46.94	10	1817–1827	Darlington, *Jour. Frank. Inst.*
60	3.36	4.03	10.97	12.45	10.07	10.06	43.56	19	1838–1856	Conrad, *Phil. Inq.*
61	3.23	3.29	9.51	13.42	9.06	8.86	40.85	8	1836–1843	Mordecai, *Jour. Frank. Inst.*
62	3.56	4.40	9.81	11.93	9.84	10.76	42.34	7	1845–1851	Conrad & Swift, *MS.*
63	3.20	2.90	9.56	11.81	10.63	8.98	40.98	8	1817–1824	Brantz, *Met. Obs. at Balt.*
64	3.68	3.97	11.13	11.04	10.52	9.31	42.00	19	1836–1854	Mil. Post.
65	3.09	2.87	10.45	10.52	10.16	11.07	41.20	4	Jul. 1838–Jun. 42	Lieut. Gilliss.
66	1.98	2.12	8.59	11.08	8.13	8.00	36.30	3	1853–1855	B. Hallowell & F. Miller, *MS.*
67	5.28	3.21	12.57	12.84	10.22	9.39	45.02	3	1851–1853	Surgeon Mil. Post.
68	2.62	2.88	10.50	17.40	11.01	8.12	47.03	5	"1772–1777"	Madison, *Jefferson's Notes on Va.*
69	3.41	4.17	9.77	15.08	10.16	10.17	45.18	19	1836–1854	Surgeon Mil. Post.
70	..	..	13.60	20.80	9.80	10.10	54.40	4	1850–1853	Carpenter, *MS.* [1754.
71	2.23	3.68	8.60	18.68	11.61	9.40	48.29	15	1738–1752	Lining, *Phil. Trans. Roy. Soc.*, Lond.

MEAN ANNUAL PRECIPITATION IN

STATIONS.	Lat.	Alt.	Jan.	Feb.	Mar.	Apl.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	
	° ′	Ft.											
Charleston, Fort Moultrie, S. C.	32.45	25	2.39	2.33	4.06	1.75	4.08	4.15	6.72	6.58	5.83	2.44	1
Whitemarsh Island, Ga.	32.00	20	2.34	1.73	3.31	1.96	4.68	3.56	4.73	5.14	4.86	1.55	2
Savannah, Ga.	32.06	30	2.76	2.53	3.69	2.11	5.20	4.84	7.57	8.32	4.26	2.55	3
Savannah, Barracks, Ga.	32.05	30	3.57	2.18	7.11	2.91	3.43	4.65	8.79	8.06	4.07	1.95	4
Augusta, Ga.	33.28	600	1.80*	1.92*	3.79*	2.46	4.42	3.91	4.62	5.61	2.10	3.23	5
Athens, Ga.	33.58	870	3.13	2.60	3.20	1.81	3.25	4.02	5.58	3.12	1.51	3.47	6
Perry, Ga.	32.31	400 ?	1.40	2.90	2.50	3.50	4.33	3.30	5.10	8.20	1.30	1.50	7
St. Augustine, Fort Marion, Fla.	29.48	25	2.09	1.63	2.34	1.56	2.00	4.27	3.24	3.03	5.85	2.42	8
Pilatka, Fort Shannon, Fla.	29.34	25	0.93	2.64	7.16	2.47	2.86	6.54	7.35	7.60	4.33	3.78	9
Fort Pierce, Indian River, Fla.	27.30	30	4.45	2.72	3.01	3.85	4.27	14.28	5.16	6.81	9.27	5.36	10
Indian Key, Fla.	24.50	10	2.36	1.37	1.30	2.00	3.29	3.30	4.52	4.22	6.57	6.30	11
Key West, Fla.	24.32	10	2.86	1.38	4.21	1.55	2.58	8.29	3.35	4.95	7.79	6.38	12
Key West, Fla.	24.32	10	1.53	1.05	1.45	1.13	5.26	2.68	2.60	3.72	4.45	3.50	13
Matanzas, Cuba	23.02	50	3.18	0.77	0.63	1.92	2.32	5.35	9.57	11.50	7.80	7.47	14
Havana, Cuba	23.09	50	3.17	1.94	1.70	2.41	3.40	5.94	5.63	2.66	4.75	4.93	15
Vera Cruz, Mexico	19.12	0	5.10	0.00	0.00	0.50	31.40	21.20	59.70	35.90	38.90	8.00	16
Fort Myers, Fla.	26.38	50	3.90	2.16	4.60	3.14	3.33	14.59	8.45	8.57	9.54	1.37	17
Fort Brooke, Tampa, Fla.	28.00	20	2.20	3.01	3.37	1.95	3.24	7.04	11.10	10.10	6.23	2.40	18
Fort Meade, Fla.	28.01	80	1.07	1.01	1.64	1.78	4.01	7.79	7.55	6.35	4.85	1.50	19
Cedar Keys, Fla.	29.07	35	2.80	5.30	1.80	1 40	0.90	6.40	4.07	11.88	4.97	3.80	20
Cedar Keys, Fla.	29.08	35	2.60	1.30	2.70	1.20	1.10	5.80	10.60	5.50	11.70	3.60	21
Pensacola, Barrancas, Fla.	30.18	20	3.87	4.95	5.87	2.94	4.05	4.66	6.80	7.23	5.25	2.41	22
Mobile, Ala.	30.42	30	8.89	5.07	5.86	4.95	3.43	5.05	4.36	8.59	4.68	2.65	23
Mount Vernon Arsenal, Ala.	31.12	150	6.80	6.04	4.59	4.21	4.62	6.14	6.30	6.40	3.05	3.92	24
Monroeville, Ala.	31.32	150 ?	3.60	7.70	4.80	6.50	7.90	5.20	7.70	8.60	1.50	1.60	25
Huntsville, Ala.	34.45	600	5.50	4.72	5.89	5.02	3.97	5.12	4.59	4.87	3.49	2.83	26
Jackson, Miss.	32.17	350 ?	5.50	6.10	2.40	5.30	3.20	4.60	6.20	3.40	0.90	2.40	27
Vicksburg, Miss.	32.24	350	5.35	4.74	4.32	3.34	4.05	3.30	4.01	3.91	3.40	2.82	28
Churchhill, Miss.	31.43	250 ?	2.95	6.10	3.95	3.38	4.03	3.12	4.19	4.74	1.20	2.39	29
Natchez, Miss.	31.36	300 ?	2.84	4.80	3.22	4.69	2.63	1.92	4.84	3.16	4.12	2.21	30
Natchez, Miss.	31.34	264	6.30	4.29	4.73	4.64	5.55	4.38	5.40	3.28	5.19	3.60	31
St. Francisville, La.	30.43	80	4.08	3.52	3.96	7.29	5.30	3.76	6.37	2.95	3.15	3.67	32
West Feliciana, La.	30.38	150	6.50	4.75	6.55	8.00	5.50	3.75	6.10	5.00	3.75	2.75	33
Baton Rouge, La.	30.26	41	5.26	4.91	4.68	5.22	5.18	5.52	7.42	6.20	3.91	2.67	34
New Orleans, La.	30.00	20	4.61	3.75	3.98	4.25	5.03	3.64	7.05	5.42	3.51	3.37	35
New Orleans Barracks, La.	29.58	10	5.61	2.90	3.90	3.29	4.10	4.97	6.66	5.65	2.20	2.74	36
New Orleans, La.	30.00	20	4.10	5.19	4.29	3.97	2.31	3.18	5.70	4.47	3.92	3.93	37
New Orleans, La.	30.00	20	4.66	2.25	2.59	6.21	2.95	6.16	6.38	5.72	5.66	1.37	38
Rapides, La.	31.08	20	6.50	3.00	4.24	4.75	6.40	7.20	8.40	5.38	1.89	3.65	39
Plaquemine, La.	29.50	50	7.00	4.00	4.50	5.75	5.65	8.75	10.55	7.00	3.30	2.10	40
Fort Jessup, near Nachitoches, La.	31.33	150 ?	4.70	2.76	5.02	4.86	3.80	4.61	3.36	2.97	3.02	3.80	41
Fort Towson, Indian Territory	34.00	300 ?	3.13	2.97	4.38	5.33	5.84	5.78	4.62	3.96	3.41	4.59	42
Fort Washita, Ind. Territory	34.14	645	1.65	2.88	3.27	3.94	5.98	5.04	3.57	2.66	3.87	3.06	43
Fort Gibson, Ind. Territory	35.47	560	1.83	2.26	2.54	4.19	4.65	4.30	2.75	2.63	2.30	3.85	44
Fort Smith, Arkansas	35.23	460	1.96	2.17	2.92	5.10	4.46	4.74	3.82	4.47	3.01	3.43	45
Fort Scott, Kansas	37.45	1000	1.92	1.18	1.79	3.70	7.08	8.13	4.55	3.69	2.30	2.66	46
Jefferson Barracks, Mo.	38.28	472	1.91	2.04	3.32	3.06	4.18	5.07	3.67	4.14	2.88	2.76	47
St. Louis Arsenal, Mo.	38.40	450	1.93	3.37	3.82	4.16	4.88	6.94	4.00	3.15	2.38	3.23	48
St. Louis, Mo.	38.37	481	2.03	2.23	3.40	3.93	4.97	6.06	3.86	4.22	2.57	3.29	49
Memphis, Tenn.	35.08	400	3.30	6.60	4.20	3.40	3.40	3.10	1.80	2.90	1.50	2.90	50
Nashville, Tenn.	36.09	533	5.01	3.98	4.91	5.20	4.94	4.41	3.84	4.40	4.94	3.68	51
Nashville, Tenn.	36.09	533	5.01	3.98	4.90	5.20	4.94	5.00	4.41	5.06	5.13	4.39	52
New Harmony, Indiana	38.11	400	4.31	4.04	3.38	4.52	2.61	4.41	3.54	4.84	2.80	2.84	53
Springdale, near Louisville, Ky.	38.00	500 ?	3.40	4.10	4.30	3.50	4.30	5.90	5.00	4.00	2.50	3.10	54
Cincinnati, Ohio	39.06	550	3.35	3.51	3.93	3.66	4.55	5.01	4.37	4.32	3.10	3.32	55
Cincinnati, Ohio	39.06	480	..	..	..	..	..	..	..	..	..	..	56
Germantown, Ohio	39.30	720	2.45	3.81	3.28	3.44	4.03	3.12	3.91	3.00	2.44	2.28	57
Portsmouth, Ohio	38.48	540	3.00	2.90	2.90	3.20	3.90	4.50	4.40	2.70	2.40	2.90	58
Marietta, Ohio	39.25	630	2.74	3.14	2.76	3.20	4.06	4.62	4.30	3.86	3.05	3.04	59
Steubenville, Ohio	40.25	670	2.38	2.16	3.43	2.61	3.37	3.91	3.44	3.57	3.41	2.70	60
Hudson, Ohio	41.15	1131	2.08	2.33	5.20	2.71	3.04	4.65	3.20	3.51	2.88	2.65	61
Hudson, Ohio	41.15	1131	3.27	2.33	2.72	4.37	2.67	3.87	2.71	2.29	2.41	2.04	62
Ann Arbor, Michigan	42.10	750	..	..	..	..	..	..	..	..	..	..	63
Detroit, Barracks, Mich.	42.20	580	2.18	1.38	2.86	2.92	2.73	3.91	3.20	2.18	3.31	2.04	64
Fort Gratiot, Mich.	42.55	598	2.19	1.76	2.82	2.51	2.69	3.74	3.37	2.88	4.10	2.66	65
Fort Mackinac, Mich.	45.51	728	1.25	0.82	1.14	1.21	2.32	2.81	3.20	2.87	2.97	2.12	66
Fort Brady, Mich.	46.30	600	1.84	1.13	1.37	1.83	2.24	2.83	3.75	3.39	4.33	3.35	67
Fort Howard, Green Bay, Wisc.	44.30	620	1.19	0.87	1.70	3.33	3.97	4.93	5.51	4.01	3.11	2.36	68
Fort Winnebago, Wisc.	43.31	770	0.91	0.82	1.07	2.26	2.25	4.24	4.21	3.01	3.62	2.00	69
Milwaukie, Wisc.	43.04	593	1.01	1.75	2.47	2.06	4.40	3.44	3.32	1.87	2.61	3.10	70
Milwaukie, Wisc.	43.04	593	1.30	0.80	1.60	2.40	2.50	4.00	3.00	2.80	3.20	1.40	71
Battle Creek, Mich.	42.20	800	..	..	..	..	..	..	..	..	..	..	72
Beloit, College, Wisc.	42.30	750	2.33	1.91	3.03	3.71	6.42	4.98	6.07	7.07	3.84	3.05	73
Athens, Illinois	39.55	750	2.30	1.90	2.90	4.90	4.40	6.90	3.20	3.10	3.80	2.50	74
Muscatine, Iowa	41.28	500 ?	2.05	1.93	2.96	3.31	4.92	4.95	3.42	6.71	3.75	3.43	75
Fort Madison, Iowa	40.38	480 ?	..	..	..	..	..	..	..	..	..	..	76
Fort Ridgely, Minnesota	44.15	1100	1.77	0.35	1.75	1.54	3.90	2.96	1.82	4.51	2.90	0.61	77
Fort Riley, Kansas	39.03	1300 ?	0.31	0.60	1.18	2.59	4.14	3.08	1.08	2.99	4.18	0.02	78
Fort Dodge, Iowa	42.28	944	0.65	0.42	1.43	3.04	3.45	5.16	1.57	1.42	2.55	3.26	79
Fort Atkinson, Iowa	43 00	700 ?	0.71	0.83	2.54	4.68	5.00	6.68	8.67	5.08	2.81	1.51	80
Fort Crawford, Wisc.	43.05	642	1.19	1.24	1.92	2.99	2.72	3.74	3.48	4.65	4.06	2.04	81
Fort Snelling, Minnesota	44.53	820	0.73	0.52	1.30	2.14	3.17	3.63	4.11	3.18	3.32	1.35	82
Fort Ripley, Minnesota	46.19	1130	0.86	0.37	1.80	1.42	3.09	5.15	5.00	2.49	4.93	1.10	83
Fort Leavenworth, Kansas	39.21	896	0.72	1.01	1.61	2.74	3.62	5.80	3.15	3.29	3.32	1.84	84
Fort Kearny, Nebraska	40.38	2360	0.50	0.48	1.55	2.68	6.57	4.36	5.07	2.62	1.83	0.88	85

RAIN AND MELTED SNOW—Continued.

	Nov.	Dec.	Spng.	Sum.	Aut.	Wint.	Year.	Yrs.	Date.	Authority.
1	1.79	2.80	9.89	17.45	10.06	7.52	44.92	12	1843–1854	Surgeon Mil. Post.
2	2.32	2.85	9.95	13.42	8.74	6.91	39.03	4–4	1850–1853	R. T. Gibson, Esq., *MS.*
3	1.65	3.20	11.00	20.72	8.46	8.48	48.66	19–6	Aug. 1836–1855	Oemler & Dr. Posey, *Alm.* & *MS.*
4	1.19	3.42	13.45	23.50	7.21	9.17	53.33	5	1843–1846; 1850	Surgeon Mil. Post.
5	1.62	2.21	10.67	14.14	6.95	5.92	40.78	4	1845–Jun. 1849	*South. Cult.* (*3 yrs., 2 from Mil. Post.)
6	1.57	3.28	8.26	12.72	6.55	9.01	36.54	4–6	1845–Jun. 1849	McCay, *Southern Cult.*
7	9.20	3.50	10.30	16.50	12.00	7.80	46.70	2–3	1851–1853	Cooper, *MS.; Agl. Rep.*
8	1.29	2.08	5.90	10.54	9.56	5.80	31.80	3–6	1844–1846; 1851	Mil. Post. (Imperfect and incomplete.)
9	1.60	1.42	12.49	21.49	9.71	5.00	48.69	3	1841–1843	Mil. Post.
10	2.21	1.59	11.13	26.25	16.84	8.76	62.98	3–3	Mar. 1852–May 55	Mil. Post.
11	3.66	0.06	6.59	12.04	16.53	3.79	38.95	2	1836–1837	Howe, *Perrine's Rep.; Am. Alm.*
12	1.18	3.13	8.34	16.60	15.35	7.37	47.65	6–6	1844–45; 50–55[9]	Surgeon Mil. Post.
13	2.36	1.05	7.84	9.00	10.31	3.63	30.78	6–3	Oct. 1832–1838	Whitehead, Gordon, *Am. Alm.*
14	3.38	1.40	4.87	26.42	18.65	5.35	55.29	1	1835	Mallory, *Am. Jour. Sci.* 1837.
15	1.80	1.43	7.51	14.23	11.48	6.54	39.76	5	1811–1815	*Sagra's Hist. Cuba.*
16	4.50	0.40	31.90	116.80	51.40	5.50	183.20	9	1822–1830	*Mayer's Mexico.* (Months 1830 only.)
17	0.96	2.27	11.07	31.61	11.90	8.33	62.91	5	1851–1855[10]	Surgeon Mil. Post.
18	2.00	2.83	8.56	28.24	10.63	8.04	55.47	15	1840–Jun. 1855	(Do.)
19	0.56	1.79	7.43	21.69	6.91	3.87	39.90	3–7	May 1851–Nov. 54	Mil. Post.
20	2.17	2.01	4.10	22.35	11.94	10.11	48.50	2–6	Jul. 1840–1842	Mil. Post.
21	2.90	2.40	5.00	21.90	18.20	6.30	51.40	2–6	1851–1853	Steele, *Agl. Rep.*
22	6.05	2.90	12.86	18.69	13.71	11.72	56.98	10	Jul. 42–Jun. 55[11]	Surgeon Mil. Post.
23	6.58	4.31	14.24	18.00	13.91	18.27	64.42	2	1841–1842	North, *Am. Alm.*
24	6.18	5.25	13.42	18.84	13.15	18.09	63.50	12–5	Oct. 1840–1854[12]	Surgeon Mil. Post.
25	5.60	4.90	19.20	21.40	8.70	16.20	65.60	4	1850–1853	Cumming, *MS.*, *Agl. Rep.*
26	3.67	4.91	14.88	14.58	9.99	15.43	54.88	12	1831–1842	Allan, *Penn. Reg.; Drake's Val. Miss.*
27	6.20	6.80	10.90	14.20	9.50	18.40	53.00	3–6	1850–1853	Oakland Institute.
28	4.72	4.93	11.71	11.22	10.94	15.02	48.89	14–6	1840–Jul. 1854	Hatch (published record).
29	4.56	7.95	11.36	12.05	8.15	17.00	49.56	4–6	1850–Jun. 1854	*Am. Alm.*
30	3.28	4.99	10.54	9.92	9.61	12.63	42.70	5	1799–1803	Dunbar, *Trans. Amer. Phil. Soc.*
31	4.54	5.85	14.92	13.06	13.33	16.44	57.75	8	1840–1847	Tooley, *Am. Jour. Sci.*
32	5.15	6.07	16.55	13.08	11.97	13.67	55.27	5	?	Barton, *Sanit. Rep.*
33	4.00	6.75	20.05	14.85	10.50	18.00	63.40	13	1820–1833	Barton, *Vital Stat. La.*
34	5.90	5.23	15.08	19.14	12.48	15.40	62.10	11	1843–1854	Surg. Mil. Post. (Ex. 8 mos. of 47 & 6 of 48.)
35	3.91	3.79	13.26	16.11	10.79	12.15	52.31	10–8	1845–Aug. 1855	Barton, *Sanitary Rep.*, &c.
36	4.68	4.20	11.29	17.28	9.62	12.71	50.90	15	1839–1853[13]	Surgeon Mil. Post.
37	4.22	5.93	10.57	13.35	12.07	15.22	51.21	3	1840–1842	Lillie, *Am. Alm.*
38	3.18	2.87	11.75	18.26	10.21	9.78	50.00	3	Aug. 1833–Jul. 36	Barton, *Am. Jour. Sci.* 1837.
39	6.75	10.25	15.39	20.98	12.29	19.75	68.41	3	1848–1850	Barton, *Vital Stat. La.*[14]
40	4.00	4.75	15.90	26.30	9.40	15.75	66.35	6	1845–1850	Barton, *Vital Stat. La.*
41	2.92	4.03	13.68	10.94	9.74	11.49	45.85	10	1836–1845	Surgeon Mil. Post.
42	4.23	2.84	15.55	14.36	12.23	8.94	51.08	14	Jun. 36–Apl. 54[15]	(Do.)
43	3.85	1.89	13.19	11.27	10.78	6.42	41.66	11–6	1843–1854	(Do.)
44	3.10	2.06	11.38	9.68	9.25	6.15	36.46	18–6	Jun. 1836–1854	(Do.)
45	3.49	2.53	12.48	13.03	9.93	6.66	42.10	15–6	May 1837–1854[16]	(Do.)
46	3.43	1.69	12.57	16.37	8.39	4.79	42.12	10–3	1843–Mar. 1853	(Do.)
47	2.38	2.42	10.56	12.88	8.02	6.37	37.83	14–6	Jul. 1840–1854	(Do.)
48	3.10	1.99	12.86	14.09	8.71	6.29	41.95	17	Jul. 1836–1854[17]	(Do.)
49	3.08	2.68	12.30	14.14	8.94	6.94	42.32	19	1837–1855	Engelmann, *MS.*, *St. Louis Med. Jour.* &c.
50	3.50	5.10	11.00	7.80	7.90	15.00	41.80	3	1851–1853	Pearson, Navy Yard.
51	3.92	2.96	14.10	14 00	12.30	12.40	52.80	7–6[18]	Jun. 1839–45; 50	Hamilton, *Am. Alm.*
52	3.97	3.00	15.04	14.47	13.49	11.99	54.99	5	1840–1844	Hamilton, *Alm.* 1846.
53	1.62	3.94	10.51	12.79	7.26	12.29	42.85	2	Jul. 1826–Jun. 28	Troost, *Darby's U. S.*
54	3.40	4.70	12.10	14.80	9.00	12.20	48.10	11	1841–1852	Young, *Alm.* & *MS.*
55	3.48	4.29	12.14	13.70	9.90	11.15	46.89	20–2	1835–Feb. 1855	Ray, *MS.*
56	..	5.80	..	..	..	..	48.63	16	1840–1855	Lea, *Horticulturist*, &c.
57	3.91	3.20	10.75	10.03	8.63	9.46	38.87	5	Dec. 1850–Dec. 55	Groneweg, *Cli. Montgom. Co., Ohio.*
58	2.80	2.60	10.00	11.60	8.10	8.50	38.20	15	1827–1841	Hempstead, *Drake's Miss. Val.*
59	3.13	3.68	10.02	12.78	9.22	9.56	41.58	28	1826–1853	Hildreth, *Am. Jour. Sci.*
60	2 92	2.37	10 41	10.92	9.03	6.91	39 69	19	1833–1851[19]	Marsh, *Am. Alm.*
61	2.52	1.92	10.95	11.36	8.05	6.33	36.69	2	1839–1840	Loomis, *Am. Jour. Sci.*
62	1.71	2.40	9.76	8.87	6.16	8.00	32.79	7	1838–1844	Loomis, *Ibid.* 1845.
63	..	..	7.30	11.20	7.00	3.10	28.60	3	?	"L. S. H.," *Mich. Agl. Rept.*
64	2.06	1.30	8.51	9.29	7.41	4.86	30.07	12–6	Apl. 1836–May 51	Surgeon Mil. Post. (Ex. July 1846–48.)
65	2.10	1 80	8.02	9.99	8.86	5.75	32.62	11	1836–1852[20]	(Do.)
66	1.92	1.24	4.67	8.88	7.01	3.31	23.87	10	1836–7; Nov. 44–54	(Do.)[21]
67	3.08	2.21	5.44	9.97	10.76	5.18	31.35	16–9	1836–1854[22]	(Do.)
68	2.37	1.30	9.00	14.45	7.84	3.36	34.65	7–6	1836–1852	(Do.) (Ex. Jul. 41–May 50)
69	2.01	1.09	5.58	11.46	7.63	2.82	27.49	9	Aug. 1836–Aug. 45	(Do.)
70	2.40	1.45	8.93	8.63	8.11	4.21	29.86	2	1851–1852	Lapham, *Trans. Wisc. Agl. Soc.*
71	2.10	2.00	6.60	9.70	6.80	4.20	27.20	7	1845–1852	Marsh, Lapham, *MS.*
72	..	..	7.50	11.20	7.10	6.80	32.70	3–6	1850–1853	Campbell.
73	3.55	2.19	13.16	18.12	10.44	6.43	48.15	4	1850–1853	Lathrop, *Wisc. Agl. Rep.*
74	2.90	2.80	12.20	13.30	9.20	7.10	41.80	10	1843–1852	Hall, *MS.*
75	3.16	2.74	11.19	15.08	10.34	6.72	44.33	10	1846–1855	Parvin, *Alm.* & *MS.*
76	..	..	15.30	15.90	14.50	4.70	50 50	4	1849–1853	McCready, *MS.*
77	1.35	1.96	7.29	9.29	4.83	4.11	25.52	2–6	Jul. 1853–1855	Surgeon Mil. Post.
78	1 38	0.35	7.91	7.15	5.58	1.26	21.90	2–2	Nov. 1853–1855	(Do.)
79	2.38	1.99	7.92	8.18	8.19	3.06	27.32	1–10	Aug. 1851–May 53	(Do.)
80	0.50	0.73	12.22	20.43	4.82	2.27	39.74	2	May 1844–May 46	(Do.)
81	1.80	1.57	7.63	11.87	7.90	4.00	31.40	10–4	May 1836–Aug. 45	(Do.)
82	1.31	0.67	6.61	10.92	5.98	1.92	25.43	19	Jul. 1836–Jun. 55	(Do.)
83	2.16	0 79	6.31	12.64	8.19	2.02	29.16	6	1850–1855	(Do.)
84	2.17	1.02	7 97	12.24	7.33	2.75	30.29	19–3	May 1836–Jul. 55	(Do.)
85	1.11	0.33	10.80	12.05	3.82	1.31	27.98	6–4	Mar. 1849–Jun. 55	(Do.)

MEAN ANNUAL PRECIPITATION IN

STATIONS.	Lat.	Alt.	Jan.	Feb.	Mar.	Apl.	May.	Jun.	Jul.	Aug.	Sep	Oct.	
	° ′	*Ft.*											
Fort Laramie, Nebraska . .	42.12	4519	0.27	0.71	1.37	1.93	5.39	2.95	1.83	0.92	1.33	1.26	1
Fort Atkinson, Kansas . . .	37.47	2330	0.04	0.49	0.96	3.38	9.34	4.35	2.30	2.30	3.85	6.81	2
Fort Arbnckle, Ind. Ter. . .	34.27	1000 ?	0.51	3.01	1.08	2.08	4.99	3.95	2.68	2.35	2.98	2.76	3
Fort Belknap, Texas . . .	33.08	1500 ?	0.06	1.07	0.83	1.36	4.90	4.74	1.14	0.43	1.65	3.79	4
Fort Worth, Texas . . .	32.40	1100 ?	1.56	4.54	3.61	4.30	6.59	3.73	2.38	2.69	2.06	3.29	5
Phantom Hill, Texas . . .	32.30	2000 ?	0.26	0.80	0.54	0.45	2.85	2.90	1.15	0.03	2.55	3.41	6
Fort Chadbourne, Texas . .	31.38	2120	0.60	1.55	0.75	1.57	6.20	4.61	3.36	2.49	3.29	3.27	7
Fort Graham, Texas . . .	31.56	900 ?	1.42	5.24	4.55	4.53	2.90	2.71	2.15	2.06	0.80	4.24	8
Fort Croghan, Texas . . .	30.40	1000 ?	1.44	4.61	4.72	3.88	3.01	3.33	3.39	1.08	2.24	2.11	9
Fort Martin Seott, Texas . .	30.10	1300	0.80	2.98	5.82	6.48	2.31	5.18	1.25	0.78	1.31	1.07	10
Fort McKavett, Texas . . .	30.55	2060	0.62	1.57	1.23	1.29	3.34	2.92	2.92	0.85	3.64	3.02	11
San Antonio, Texas . . .	29.25	600	0.80	4.41	2.94	2.80	2.89	6.15	3.23	0.84	2.80	1.05	12
Corpus Christi, Texas . . .	27.47	20	3.96	2.37	1.25	4.01	4.68	5.63	4.89	2.91	6.73	2.37	13
Fort Ewell, Texas	28.05	200 ?	0.76	4.73	0.71	1.12	5.11	7.85	2.90	2.43	4.96	2.36	14
Fort Merrill, Texas . . .	28.17	150 ?	0.23	2.09	0.09	1.62	3.43	4.10	6.13	3.40	4.60	1.38	15
Matamoros, and Fort Brown, Tex.	25.54	50	1.61	2.25	1.20	0.56	2.21	4.55	2.89	2.76	7.18	5.70	16
Ringgold Barracks, Texas . .	26.23	200 ?	1.24	1.18	0.72	1.08	2.69	3.47	2.13	1.50	3.22	2.15	17
Laredo, Fort McIntosh, Texas .	27.31	400 ?	0.26	1.46	0.59	1.03	2.45	3.61	2.48	1.24	3.02	0.96	18
Eagle Pass, Fort Duncan, Texas .	28.42	800 ?	0.26	1.27	1.34	0.71	1.50	5.63	3.35	0.93	3.28	1.43	19
Fort Inge, Texas	29.09	845	0.64	2.21	1.79	1.26	3.01	5.38	3.66	2.02	2.21	2.70	20
Fort Lincoln, Texas . . .	29.22	900	0.13	4.01	3.50	1.86	2.89	2.07	1.00	0.39	1.53	1.36	21
Fort Clark, Texas	29.17	1000 ?	0.30	1.36	0.86	1.14	2.70	5.03	1.98	1.52	2.37	2.21	22
El Paso, New Mexico . . .	31.44	3830	0.00	0.90	0.00	0.00	0.70	0.02	0.57	2.97	1.88	1.07	23
Fort Fillmore, N. M. . . .	32.13	3937	0.01	0.10	0.21	0.20	0.34	0.54	2.50	1.40	1.26	0.54	24
Fort Webster, Copper Mines, N. M.	32.48	6350	0.40	1.00	0.07	2.23	1.14	2.98	3.67	2.75	2.37	0.79	25
Fort Thorne, N. M. . . .	32.38	4500	0.05	0.10	0.47	0.23	0.58	0.08	2.23	6.01	3.50	0.00	26
Fort Conrad, Valverde, N. M. .	33.34	4576	0.06	0.11	0.14	0.04	0.33	0.78	1.28	1.18	1.25	0.50	27
Soeorro, N. M.	34.10	4560	0.04	0.48	0.60	0.43	0.07	0.08	0.84	1.31	0.24	1.81	28
Albuquerque, N. M. . . .	35.06	5032	0.14	0.20	0.38	0.32	0.40	1.72	1.36	2.37	0.86	0.50	29
Lagunas, N. M.	35.03	6000	0.30	1.61	0.36	0.75	0.12	0.14	0.55	1.22	3.60	1.59	30
Santa Fé, N. M.	35.41	6846	0.31	0.57	1.29	0.80	0.74	1.32	4.18	3.40	2.55	1.60	31
Las Vegas and Fort Union, Texas	35.35	6418	0.19	0.99	0.37	0.53	1.57	2.00	4.07	3.55	2.45	1.25	32
Taos, or Cant. Burguin, N. M. .	36.30	8000	1.06	1.04	0.20	0.08	0.20	0.83	2.64	..	·0.21	0.13	33
Fort Massachusetts, N. M. . .	37.32	8365	0.23	0.72	0.94	0.42	2.14	0.74	2.59	2.05	1.39	1.10	34
Fort Defiance, N. M. . . .	35.44	7200	1.00	0.88	1.68	0.51	0.72	1.11	1.57	3.77	2.69	1.05	35
Fort Yuma, California . . .	32.43	120	0.03	0.39	0.20	0.07	0.00	0.00	0.16	1.13	0.58	0.13	36
San Diego, Cal.	32.42	150	0.83	2.01	1.40	0.77	0.57	0.15	0.01	0.39	0.03	0.05	37
San Luis Rey, Cal. . . .	33.13	20	0.09	0.95	0.21	0.21	..	..	0.00	0.00	0.00	0.20	38
Del Chino and Jurupa, Cal. . .	34.00	1000 ?	0.95	1.50	3.12	0.33	1.14	0.00	0.00	0.09	0.00	0.00	39
Fort Tejon, Cal.	35.03	1447	..	..	1.58	3.78	0.61	0.00	0.00	0.00	1.00	0.05	40
Monterey, Cal.	36.36	140	1.68	1.50	3.27	0.63	0.53	0.13	0.08	0.00	0.01	0.33	41
Fort Miller, Cal.	37.00	402	1.34	1.69	6.40	1.81	1.36	0.01	0.01	0.00	0.05	0.16	42
San Francisco, Cal. . . .	37.48	80	3.33	2.67	4.14	2.85	0.57	0.08	0.00	0.01	0.19	0.63	43
San Francisco, Cal. . . .	37.48	150	3.23	3.31	4.61	3.72	0.48	0.02	0.00	0.01	0.07	0.63	44
Benicia, Cal.	38.03	64	2.18	1.66	3.48	2.33	0.59	0.01	0.00	0.00	0.01	0.69	45
Saeramento, Cal.	38.33	50	6.31	0.60	5.60	1.40	0.01	..	0.00	0.00	0.00	0.20	46
Sacramento, Cal.	38.33	50	2.67	3.46	4.20	1.50	0.21	0.31	0.00	0.01	0.00	1.01	47
Camp Far West, Cal. . . .	39.07	150 ?	1.83	0.65	6.74	3.06	0.86	0.00	0.00	0.00	0.36	0.06	48
Fort Reading, Cal. . . .	40.30	400	3.75	4.09	4.53	3.92	2.85	0.31	0.00	0.08	0.01	0.92	49
Fort Humboldt, Cal. . . .	40.46	50	4.07	5.62	5.97	5.58	1.96	1.15	0.00	0.00	0.65	2.11	50
Fort Jones, Cal.	41.36	2570	1.97	2.07	3.13	1.50	0.75	0.52	0.16	0.21	0.00	2.33	51
Fort Orford, Oregon . . .	42.44	50	8.81	6.35	8.24	5.64	5.24	1.06	0.16	1.78	2.34	7.31	52
Fort Lane, Oregon	42.25	1700	4.38	1.27	3.26	0.98	1.33	1.03	..	..	..	0.32	53
Fort Vaneouver, Oregon . .	45.40	50	9.62	3.38	3.79	2.74	2.75	2.68	2.85	0.70	1.12	2.78	54
Astoria, Oregon	46.11	50	27.00	10.95	6.10	4.38	5.95	2.85	0.00	1.15	1.87	6.70	55
Steilacoom, Wash. Territory .	47.10	300	9.54	5.16	4.56	4.77	1.86	1.97	0.34	1.54	2.67	4.43	56
Dalles of Columbia, Oregon . .	45.36	350	3.16	1.04	1.07	0.99	0.57	0.13	0.03	0.26	0.76	0.69	57
Sitka, Russian America . .	57.03	20	7.80	7.32	6.20	6.83	5.29	3.79	4.15	7.81	11.27	12.32	58

1 At the Military Posts, the series for a period of years would, in every case, necessarily be under the care of several officers in snccession, as they were transferred according to the exigeucies of the service. For this reason, their names cannot be given. All the results at these posts are taken from the Army Meteorological Register last published.

2 The gauge is said to have been badly placed iu this case, receiving only the water falling vertically.

3 All the observations at tho New York academies were taken by the principals and professors, under a system directed by the Regents of the University. So many changes occurred iu the 25 years of this period that their names cannot be given here. They may be found in the quarto volume of results of the New York observations, published by the State in 1855.

4 At this point, and at Lansingburg, the quantities for the winter months are believed to be too small; those at Albany are relied upon as being quite correct for this vicinity.

5 Iucluding observatious for 1789 by Dr. Williams, for 1806 by Fowler, and for 1828, 1832, and 1833 by Prof. Thompson. *Thompson's Hist. Vt.*

6 Except July 1846 to June 1849, and closing at April 1852.

7 1829, '31, '32, '34 to '36, '40 and '41, omitted in the first series with this refereuce. In the others, with many at the New York academies, several years included within the extreme years named are not embraced, aud it is impossible to give all the exceptions. All incomplete years were thrown out in the preparation of those statistics, unfortuuately, and much valuable matter thus exeluded.

8 At Lambertville, 2 years, June '45 to June '47, are omitted; and the mean for the mouths and seasons is for but 9 years, July 1843 to July 1845, and July 1847 to June 1854.

9 Key West; begins with February 1844 to Jnly 1845; and again from July 1850 to Juue 1855. The mean of this and the succeeding series together is probably nearer the true quantity at Key West than either alone. As the periods are nearly equal, we may tako their mean as they stand, giving 39.22 inches as the quantity for the year, 12.8 for the summer, aud 5.56 inches for the winter.

10 Fort Brooke, Fla.: Sep. 1848 to June 1849, with Nov. 1850 to April 1851 omitted.

RAIN AND MELTED SNOW—Continued.

	Nov.	Dec.	Spng.	Sum.	Aut.	Wint.	Year.	Yrs.	Date.	Authority.
1	1.37	0.65	8.69	5.70	3.96	1.63	19.98	6	Sep. 1849–Jul. 55	Surgeon Mil. Post.
2	1.39	1.60	13.68	7.15	12.05	2.13	35.01	1	Aug. 1852–Jul. 53	(Do.)
3	3.16	1.02	8.15	8.98	8.90	4.54	30.57	4–10	Oct. 1850–Jul. 55	(Do.)
4	1.41	0.62	7.09	6.31	6.85	1.75	22.00	2–9	Oct. 1852–Jun. 55	(Do.)
5	4.14	1.97	14.50	8.80	9.49	8.07	40.86	3–9	Dec. 1849–Aug. 52	(Do.)
6	1.34	0.94	3.84	4.08	7.30	2.00	17.22	1–6	Sep. 1852–Feb. 54	(Do.)
7	2.43	1.76	8.52	10.46	8.99	3.91	31.88	3	May 1852–Jun. 55	(Do.)
8	4.73	5.25	11.98	6.02	9.77	11.91	40.58	3–6	Mar. 1850–Aug. 53	(Do.)
9	3.89	2.86	11.61	7.80	8.24	8.91	36.56	4–3	Jun. 1849–Aug. 53	(Do.)
10	2.68	1.87	14.61	7.21	5.06	5.65	32.63	2–3	1850–Mar. 52	(Do.)
11	1.39	0.48	5.86	6.09	8.05	2.67	23.27	3	Apl. 1852–Jun. 55	(Do.)
12	3.72	2.14	8.63	10.22	7.57	7.35	33.77	3	Sep. 1849–Oct. 52	(Do.)
13	1.05	1.26	9.94	13.43	10.15	7.59	41.11	2–6	[23]	(Do.)
14	0.49	1.16	6.94	13.18	7.81	6.65	34.88	2	Oct. 1852–Sep. 54	(Do.)
15	1.82	1.93	5.14	13.63	7.80	4.25	30.82	3	[24]	(Do.)
16	2.87	1.39	3.97	10.20	15.75	5.25	35.17	6	1850–1855	(Do.)
17	0.94	0.63	4.49	7.10	6.31	3.05	20.95	6	Sep. 1849–Jul. 55	(Do.)
18	1.08	0.48	4.07	7.33	5.06	2.20	18.66	6	Jul. 1849–Jun. 55	(Do.)
19	1.61	0.89	3.55	9.91	6.32	2.42	22.20	5–8	Oct. 1849–May. 55	(Do.)
20	2.08	1.03	6.06	11.06	6.99	3.88	28.00	5–6	Nov. 1849–Apl. 55	(Do.)
21	2.01	0.98	8.25	3.46	4.90	5.12	21.73	2	1850–51–52	(Do.)
22	1.78	0.65	4.60	8.53	6.36	2.31	21.80	3	Aug. 1852–Jun. 55	(Do.)
23	2.30	0.80	0.70	3.56	5.25	1.70	11.21	1–6	Aug. 1850–Aug. 51	(Do.) (With last half of 1854)
24	1.50	0.63	0.75	4.44	3.30	0.74	9.23	3–9	Sep. 1851–Jun. 54	(Do.)
25	1.87	0.17	3.44	9.40	5.03	1.57	19.44	2	1852–1853	(Do.)
26	0.99	0.35	1.28	8.32	4.49	0.50	14.59	1–6	1854–May 1855	(Do.)
27	0.78	0.31	0.51	3.24	2.53	0.48	6.76	3–9	Oct. 1851–Jun. 55	(Do.)
28	1.34	0.62	1.10	2.23	3.39	1.14	7.86	2	Nov. 1849–Aug. 51	(Do.)
29	0.71	0.46	1.10	5.45	2.07	0.80	9.42	4–8	Feb. 1850–May. 55	(Do.) (Ex. Aug. 1851–Mar. 52.)
30	0.68	1.13	1.23	1.91	5.87	3.04	12.05	2	1850–1851	(Do.)
31	1.87	1.20	2.83	8.90	6.02	2.08	19.83	3–6	Sep. 1852–Jun. 55	(Do.) (With 8 mos. of 1850.)
32	1.42	0.85	2.47	9.62	5.12	2.03	19.24	5	Sep. 1850–Jul. 55	(Do.) (Ft. Union, lat. 35° 54',
33	1.03	0.06	0.48	3.47	1.37	2.16	7.48	1	Sep. 1854–Jul. 55	(Do.) [alt. 6670 ft.)
34	6.34	1.88	3.50	5.38	8.83	2.83	20.54	2	[25]	(Do.)
35	1.10	1.09	2.91	6.45	4.84	2.97	17.17	3–9	May 1852–Feb. 56	(Do.)
36	0.16	0.30	0.27	1.30	0.86	0.72	3.15	3–9	Jun. 1852–1855	(Do.) (With 1st 5 mos. of 51.)
37	1.16	3.06	2.74	0.55	1.24	5.90	10.43	5–6	1850–Jun. 1855	(Do.)
38	3.28	2.22	0.21	0.00	3.48	3.26	6.95	1	Jun. 1850–Mar. 51	(Do.)
39	1.67	4.97	4.59	0.09	1.67	7.42	13.77	2	Jul. 1851–Mar. 54	(Do.) (Ex. Nov. 1851–Aug. 52.)
40	1.56	0.75	5.97	0.00	2.61	..	..	1	1855	(Do.)
41	1.31	2.73	4.43	0.21	1.65	5.91	12.20	4[26]	1847–1852	(Do.)
42	2.59	6.76	9.57	0.02	2.80	9.79	22.18	4–6	Jul. 1851–1855	(Do.)
43	2.14	5.34	7.56	0.09	2.96	11.34	21.95	5	1851–1855	Gibbons, *Cala. Jour.* & *Am. Jour. Sci.*
44	2.05	4.71	8.81	0.03	2.75	11.25	22.84	3–9	Jul. 1852–1855	Surgeon Mil. Post. (With Mar.–Jun. 50.)
45	1.95	3.72	6.40	0.01	2.65	7.56	16.62	5–6	1850–Jun. 1855	(Do.)
46	6.41	5.20	7.01	0.00	6.61	12.11	25.73	1	Jul. 1849–May 50	(Do.)
47	0.65	2.15	5.91	0.32	1.66	8.28	16.17	1	Apl. 1854–Mar. 55	Dr. Logan, *Alm.* 1856.
48	1.98	4.31	10.66	0.00	2.40	6.79	19.85	1–6	Oct. 1850–Mar. 52	Surgeon Mil. Post.
49	3.96	4.60	11.30	0.39	4.89	12.44	29.02	3	Jun. 1852–Jun. 55	(Do.)
50	2.10	5.34	13.51	1.18	4.87	15.03	34.56	2	1854–1855	(Do.) (Ex. Apl. 1855.)
51	2.97	1.16	5.38	0.89	5.30	5.20	16.77	2–6	1853–May 1855	(Do.)
52	10.27	14.43	19.12	3.00	19.92	29.59	71.63	2–6	1852–1855	(Do.)
53	3.37	6.55	5.57	..	3.60	12.20	21.37	1	1855	(Do.)
54	7.70	7.27	9.28	6.23	11.60	20.27	47.38	5	Dec. 1849–Jun. 55	(Do.)[27]
55	13.20	6.20	16.43	4.00	21.77	44.15	86.35	1–2	Aug. 1850–Sep. 51	(Do.)
56	8.73	7.92	11.19	3.85	15.83	22.62	53.49	6	Nov. 1849–1855	(Do.)
57	2.33	2.78	2.63	0.42	3.78	6.98	13.81	4	Oct. 1852–1855	(Do.) (With Jul. 50–Mar. 51.)
58	8.51	8.65	18.32	15.75	32.10	23.77	89.94	7	1847–1853	*Russ. Ann.* & Dove, *Pogg. Ann.* 1855.

[11] Barrancas: Portions of 1845, '46, and '47, all of 1848, '49, and '50, and months of 1852 and '53 omitted.

[12] Mount Vernon Arsenal: Last 6 months of 1841, 1842, and first 4 months of 1844 omitted. From this series, the quantities for 1853, 106.5 inches, have been rejected, as being apparently overmeasured; adding this year, the annual mean becomes 66.97 inches.

[13] New Orleans: This record is much interrupted for the summer months. The first four years, with 1847 and 1848, are the only complete ones; all others omit four to five months of the warmer months, by a transfer of the troops to a summer station on the coast. Adding the quantities observed at the coast stations, and thus complete the year, the averages are found to differ very little from the series without them.

[14] Rapides: These quantities, with those at Plaquemine and St. Francisville, are taken from Dr. Barton's projected curves for the months, the yearly summaries only being given by him in the report from which they are taken.

[15] Fort Towson: May 1846 to May 1849, and Dec. 1851 to Sept. 1852, omitted.

[16] Fort Smith: July 1850 to May 1852 omitted.

[17] St. Louis Arsenal: The omissions are the last 3 months of 1849, April to Sept. 1840, and 1842.

[18] The summaries for the months at Nashville embrace only 5½ years; June 1839 to 1844.

[19] Steubenville: Means for months and seasons 13 years only.

[20] Fort Gratiot: Omissions, from June 1837 to June '39, July '46 to June '49; and the record ends with May 1852.

[21] Mackinac: July 1836 to March 1857. The omissions are the last 7 months of 1848, and the first 6 of 1852.

[22] Brady: Beginning in July 1836, with omissions from June 1848 to Dec. 1849, and for the first 9 months of 1852.

[23] Corpus Christi: First 9 months of 1846, last 5 of 1849, last 9 of 1851, and May to Sept. 1854.

[24] Fort Merrill: Last 9 months of 1851, June to July 1852, and Aug. 1853 to June 1855.

[25] Fort Massachusetts: Oct. 1852–Sept. 1853; May 1854–June 1855 (except Nov. 1854 and March 1855).

[26] Monterey: The dates are, May 1847–Aug. 1848; May 1849–Dec. 1850; July 1851–Aug. 1852.

[27] Vancouver: April to Nov. 1851, and July to Sept. 1852 omitted.

MEAN QUANTITIES OF RAIN IN THE TEMPERATE

STATIONS.	Lat.	Alt.	Jan.	Feb.	Mar.	Apl.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	
	° ′	*Ft.*											
WESTERN AND SOUTHERN EUROPE.													
London	51.30	50	1.46	1.25	1.17	1.28	1.64	1.74	2.45	1.81	1.84	2.09	1
Oxford	51.46	150 ?	1.90	1.69	1.45	1.84	1.88	2.57	2.86	2.68	2.87	2.84	2
Hereford, Central England . .	52.00	200 ?	2.27	2.35	1.81	2.30	2.07	2.36	2.79	2.38	2.88	3.18	3
Gosport, South England . .	50.50	50	2.58	2.21	2.03	2.24	1.92	1.75	2.57	2.34	3.21	3.25	4
Penzance, Cornwall . . .	50.08	50	3.83	3.26	3.87	1.82	3.07	2.14	2.97	3.49	3.44	5.67	5
Armagh, North Ireland . .	54.20	150 ?	3.75	2.88	2.42	2.22	2.23	2.86	3.19	2.82	2.58	3.48	6
Townley, Lancashire, England .	54.00	200 ?	3.20	2.34	3.24	3.07	2.54	3.57	3.14	4.43	3.83	4.39	7
Manchester	53.29	150 ?	2.31	2.57	2.10	2.01	2.89	2.50	3.70	3.66	3.28	3.92	8
Liverpool	53.24	50	2.18	1.85	1.52	2.10	2.57	2.81	3.66	3.31	3.65	3.72	9
Aberdeen, Scotland . . .	57.09	150 ?	2.63	2.15	2.24	1.00	2.19	2.33	2.36	2.41	3.26	3.00	10
Glasgow, Scotland	55.51	50 ?	1.60	1.74	1.18	0.98	1.64	1.34	2.30	2.75	1.62	2.30	11
Lyndon, Rutland, England . .	52.40	150 ?	1.57	1.38	1.32	1.46	1.61	2.25	2.52	2.25	2.02	2.16	12
Bergen, Norway	60.00	30	7.76	7.35	7.26	4.54	3.96	4.94	5.23	8.43	10.93	8.25	13
Stockholm, Sweden . . .	59.21	30	0.93	0.39	0.35	0.40	1.42	1.54	2.29	3.98	3.07	1.99	14
Copenhagen, Denmark . . .	55.30	30	0.95	0.99	0.72	0.93	1.19	1.72	2.32	2.82	1.87	1.57	15
Konigsberg, Prussia . . .	52.42	30	1.61	2.31	1.55	0.98	1.44	2.87	2.32	2.80	2.98	2.84	16
Berlin, Prussia	52.45	115	1.59	2.17	1.48	2.18	2.00	3.41	1.86	1.94	1.55	1.92	17
Potsdam, Prussia	52.21	180 ?	1.24	1.73	1.07	1.98	1.86	2.85	1.80	1.76	1.53	1.34	18
Manheim (Rhine)	49.29	432	1.63	1.14	1.44	1.95	2.04	2.69	2.45	2.15	2.17	1.98	19
Brussels, Belgium	50.50	220	2.82	2.11	2.19	1.26	2.26	2.75	3.44	2.63	2.46	2.96	20
Dijon, France	47.20	800 ?	2.39	2.02	1.93	2.52	2.63	2.76	2.05	2.69	2.61	3.32	21
Paris	48.50	222	1.40	1.65	1.59	1 66	2.28	2.14	1.92	1.86	2.42	1.85	22
Geneva, Switzerland . . .	46.12	1280	2.00	1.00	1.42	3.94	2.58	3.89	2.85	4.01	3.74	4.83	23
Lausanne, Switzerland . . .	46.30	1680	2.00	2.82	2.57	1.78	3.07	4.61	3.72	5.06	2.84	5.13	24
St. Bernard, Alps	45.50	7670	9.12	6.99	5.45	6.29	5.27	3.94	2.92	2.69	5.66	7.81	25
Udine, N. E. Italy	46.03	250	4.56	3.25	4.53	5.65	4.58	7.28	6.68	5.02	6.05	7.59	26
Milan, Italy	45.28	390	2.84	2.08	2.25	3.07	3.73	3.17	2.94	3.07	3.27	4.33	27
Rome, Italy	41.54	170	3.41	2.20	2.63	2.29	2.35	1.67	0.72	1.00	2.13	4.66	28
Naples, Italy	40.52	150	3.15	2.79	3.12	2.38	1.74	1.48	0.57	0.88	2.43	4.24	29
Catania, Sicily	37.50	50	3.66	2.26	4.12	2.27	0.90	0.33	0.13	0.17	2.01	5.12	30
Padna, near Venice, Italy . .	45.24	150 ?	2.22	1.55	3.04	2.39	3.17	2.76	3.08	3.59	3.50	5.09	31
Marseilles, S. France . . .	43.18	150	1.45	2.01	1.10	1.75	1.82	0.74	0.40	1.03	2.03	3.35	32
Alais, near Marseilles . . .	44.12	437	3.42	2.42	2.41	3.32	3.55	1.79	2.05	1.73	5.21	5.53	33
Bordeaux, France	44.50	30	3.51	3.65	2.57	2.88	1.79	2.49	1.35	3.55	2.69	4.24	34
Viviers, Rhone, France . .	44.30	?	2.64	1.81	2.10	2.86	3.12	2.70	2.02	2.48	4.40	5.04	35
Madeira Islands	32.50	50	9.59	2.60	2.91	0.52	1.68	0.52	0.10	1.68	0.97	2 86	36
Algiers	36.47	310	5.03	5.84	3.11	3.50	1.73	0.29	0.01	0.30	1.30	2.88	37
INTERIOR OF EUROPE AND ASIA.													
St. Petersburg, Russia . . .	59.56	20	0.87	0.88	0.91	0.73	1.24	1.71	2.80	2.23	1.73	2.07	38
Gorigoretzk, Russia . . .	54.30	500	0.95	0.95	0.97	1.02	1.49	2.25	3.12	2.37	1.54	1.79	39
Orel, Central Russia . . .	52.58	500 ?	2.17	1.28	2.74	1.40	2.23	2.34	3.01	3.15	0.79	1.94	40
Simferopol, Crimea . . .	44.57	200 ?	0.67	0.46	1.01	0.73	1.47	2.66	2.77	0.58	1.52	0.87	41
Koursk, S. Russia	51.44	500 ?	0.29	0.66	1.23	1.62	2.72	3.39	2.49	3.19	1.33	0.52	42
Lougan, S. Russia	48.35	400 ?	0 75	0 66	0.82	1.00	1.75	2.42	1.29	1.28	0.62	1 02	43
Kutais, E. shore of Black Sea .	42.31	470	6 04	6.43	4.48	2.16	4.71	4.01	4.77	5.79	4.43	4.47	44
Redout-Kale, E. shore of Black Sea	42.16	20	5.35	6.12	4.69	2.86	3.41	4.79	7.21	6.55	6.31	2.99	45
Tiflis, Caucasus	41.42	1500	0.35	0.73	1.94	1.16	3.15	3.03	3.05	1.54	1.77	0.72	46
Lenkoran, S. Caspian Sea . .	38.44	—65	3.37	1.72	4.15	4.85	1.38	1.33	0.12	1 98	6.18	3.88	47
Bakou, S. Caspian Sea . . .	40.22	—53	1 06	0.89	1.37	0.47	1.50	0.81	0.31	0.36	0.73	2.23	48
Ooroomiah, Persia . . .	37.28	7334	1.69	2.84	4.06	5.22	2.43	0.43	0.00	0.48	0.95	1.48	49
Bogoslovsk, Asiatic Tartary . .	49.45	600	0.57	0.81	0.51	1.07	1.66	1.86	3.48	2.81	1.47	1.34	50
Catherinburg, Ural Mountains .	56.50	770	0.21	0.23	0.35	0.55	1.66	3.27	3.49	2.60	0.97	0.66	51
Barnaoul, Russia in Asia . .	53.20	400	0.23	0.19	0.26	0.45	1.06	1.99	1.89	2.52	1.24	0.83	52
Nertchinsk, Russia . . .	51.18	2100	0.10	0.07	0.23	0.30	1.15	3.02	4.60	4.43	2.27	0.73	53
Pekin, China	39.54	100 ?	0.09	0.25	0.28	0.75	1.64	4.61	10.06	5.84	2.21	0.84	54
Ajansk (Okhotsk)	56.27	?	0.53	0.41	0.45	0.45	2.41	2 27	3.86	9.01	10.33	3.24	55
Canton, China	23.07	40	0.60	1.60	2.10	4.60	12.10	10.80	7.20	9.90	10.60	6.10	56

NOTES.—Gorigoretzk and Orel are south of St. Petersburg and of Moscow respectively, and on the great plain of Central Russia. Simferopol represents most parts of the Crimea. Koursk and Lougan represent the south of Russia below Orel. Kutais and Redout-Kale are on the most rainy coast of the Black Sea. Tiflis in the valley of the mountain region of the Caucasus. Lenkoran and Bakou are on the immediate shore of the Caspian Sea, most of which is extremely deficient in rain. They are below the ocean level according to the most recent measurements. Bogoslovsk and Catherinburg are in the mining districts of the Ural Mountains. Barnaoul is a mining town in the great plain of Asiatic Russia. Nertchinsk is beyond the principal Mountain ranges of Siberia, and on the Amoor River. Pekin is south of the deserts and mountains, and at sea level; Ajansk is on the sea of Okhotsk. The observations set down for Canton were mainly taken at Macao.

In an Essay on the British Climate by Mr. Whitley) *Journal of Royal Agricultural Society of England* for 1854) a large list of stations is given with the mean quantity of rain for the year only. A few are here cited, as the monthly distribution cannot be obtained.

ON THE WEST COAST, NORTH OF LIVERPOOL.

	Yrs.	Inches.	
Seathwaite, ...	4	146.4	Phil. Trans.
Gatesgarth, alt. 326 ft ;	4	121.4	(Do.)
Keswick, alt. 258 ft.; .	4	63.6	(Do.)
Applegarth Manse,	. 10	33.6	(Do.)
Glasgow, . . .	. 30	36.0	McCulloch.
Dunmoor, . . .	. ..	56.0	Milner.
Sandwick, . . .	. 7	36.8	Phil. Mag. (1842–S.)

LATITUDES OF THE EASTERN CONTINENT.

	Nov.	Dec.	Spng.	Sum.	Aut.	Wint.	Year.	Yrs.	Date.	AUTHORITY.	
1	2.22	1.74	4.09	6.00	6.15	4.45	20.69	40	....	*Dalton.*	
2	2.68	1.84	5.17	8.11	8.39	5.43	27.10	4	1851–1854	Radcliffe Observations, 15th volume.	
3	3.41	2.85	6.18	7.53	9.47	7.47	30.68	24	....		
4	3.73	3.22	6.19	6.66	10.19	8.01	31.05	26	....		
5	5.18	6.01	8.76	8.60	14.29	13.10	44.75	7	1821–1827	*Edinb. Phil. Mag.* 1828.	
6	3.35	2.97	6.87	8.87	9.41	10.97	36.12	12	....	[*London*, No. 208, p. 51, 1694.	
7	4.33	3.33	8.85	11.14	12.55	8.87	41.41	15	1677–86; 1689–93	R. Townley; *in Phil. Trans. Roy. Soc.*	
8	3.36	3.83	7.00	9.86	10.56	8.71	36.13	33	....	Dalton.	
9	3.44	3.29	6.19	9.78	10.81	7.32	34.10	18	....	*Dalton.*	
10	2.69	2.61	5.43	7.10	8.95	7.39	28.87	4	....		
11	1.90	1.98	3.80	6.39	5.82	5.32	21.33	17	....	Dalton.	
12	1.96	1.74	4.39	7.02	6.14	4.69	22.24	45	1736–1780	Barker, *Phil. Trans.* 1781.	
13	10.57	8.39	15.76	18.60	29.75	23.50	87.61	10	....	*Dove.*	
14	1.88	1.43	2.17	7.81	6.94	2 75	19.67	8	....	*Dove.*	
15	1.69	1.58	2.84	6.86	5.13	3.52	18.35	17	....	*Dove.*	
16	2.44	2.09	3.97	7.99	8.26	6.01	26.23	6	....	*Dove.*	
17	1.98	1.48	5.66	7.21	5.45	5 24	23.56	6	....	*Dove.*	
18	1.74	0.99	4.91	6.41	4.61	3.96	19.90	8	....	*Dove.*	
19	1.50	1.33	5.43	7.29	5.65	4.10	22,47	12	....	*Ann. Met. de France.*	
20	2.79	2.27	5.71	8.82	8.22	7.20	29.96	6	....	Brussels, *Met. Transactions.*	
21	3.34	2.89	7.07	7.49	9.27	7.31	31.15	20	....	*Annuaire Meteorologique.*	
22	2.24	1.63	5.53	5.92	6.51	4.68	22.64	30	1816–1845	Observatory Record; *Annuaire Met.* 1849.	
23	2.53	0.97	7.95	10.76	11.11	3.95	33.77	5	(Recent)	*Ann. Meteorologique de France.*	
24	2.88	2.01	7.42	13.39	10.85	6.83	38.49	8	(Recent)	(Do.)	
25	7.09	5.56	17.02	9.56	20.57	21.56	68.81	12	1841–1852	(Do.)	
26	6.10	5.61	14.76	18.98	19.74	13.42	66.90	16	....	*Dove.*	
27	4.13	3.13	9.05	9.18	11.73	8.05	38.01	68	....	*Dove.*	
28	4.10	3.70	7.27	3.39	10.89	9.31	30.86	40	....	*Dove.*	
29	3.85	3.01	7.24	2.93	10.52	8.95	29.64	14	....	*Dove.*	
30	3.33	3.83	7.29	0.63	10.46	9.75	28.13	8	....	*Dove.* [*Lond.* 1733.	
31	3.76	3.48	8.60	9.43	12.36	7.25	37.63	6	1725–1730	Marquis Poleni, *in Trans. Roy. Society*	
32	2.71	1.77	4.67	2.17	8.00	5.23	20.16	20	....	*Ann. Met. de France.*	
33	4.39	3.19	9.28	5.58	15.13	9.03	39.02	35	....	(Do.)	
34	3.44	1.81	7.25	7.39	10.34	8.98	34.00	6	....	(Do.)	
35	4.45	2.55	8.08	7.20	13.89	7.00	36.17	40	....	*Dalton.*	
36	4.13	4.31	5.11	2.30	6.96	16.50	30.87	4	1747–1750	Dr. Heberden, *Phil. Trans.* 1751–52.	
37	6.09	6.91	8.34	0.60	10.27	17.78	36.99	10	1838–1847	*Annuaire Meteorologique*, 1850.	
38	1.31	1.18	2.89	6.73	5.11	2.93	17.65	16	?	*Dove.*	Long. E. G. 30.18
39	0.72	0.90	3.48	7.74	4.05	2.80	18.07	6	1844–1849	*Annales Obs. Phys.* 1848.	30.25
40	1.89	1.70	6.37	8.60	4.62	5.15	24.64	4	1842–1845	*Annales*, 1848.	35.30
41	1.01	1.07	3.22	6.01	3.40	2.20	14.83	5	?	*Dove.*	34.04
42	1.18	1.00	5.57	9.27	4.02	1.95	20.81	4	?	*Dove.*	36.14
43	1.38	0.88	3.57	4.99	3.02	2.28	13.87	15	?	*Dove.*	39.21
44	4.50	7.67	11.35	14.57	11.40	20.14	59.44	3	1851–1853 ?	*Dove.*	42.47
45	2.21	5.76	10.96	18.55	11.51	17.76	58.25	3	1851–1853	*Dove.*	41.03
46	1.02	0.80	6.25	7.62	3.51	1.88	19.26	6	1848–1853 ?	*Dove.*	45.17
47	6.92	7.11	10.39	3.43	16.77	12.21	42.78	3	1851–1853	*Dove*	48.53
48	1.11	2.37	3.34	1.48	3.07	4.32	13.38	3	1851–1853	*Dove.*	49.44
49	0.95	1.29	11.71	0.91	3.08	5.81	21.51	1¼	1853–Mar. 1854	Stoddard, *Am. Jour. of Science.*	45.00
50	0.97	0.46	3.24	8.15	3.78	1.84	17.02	15	?–1853	*Dove.*	59.59
51	0.44	0.33	2.56	9.36	2.02	0.76	14.76	17	?	*Dove.*	60.34
52	0.69	0.45	1.78	6 40	2.46	0.87	11.80	15	1841–1854	*Dove.*	83 27
53	0.39	0.16	1.68	12.06	3.39	0.32	17.45	12	?	*Dove.*	119.20
54	0.17	0.19	2.67	20.51	3.22	0.53	26.93	7	1847–1853	*Dove.*	117.26
55	1.57	0.71	3.31	15.14	15.15	1.65	35.24	2	?	*Dove.*	138.26
56	2.40	1.10	18.80	27.90	19.30	3.30	69.30	14	1812–16; 1819–31	*Dove*, "*Observer Bletterman.*"	113.14

IN THE SOUTHWEST OF ENGLAND AND IRELAND.

	Yrs.	Inches.	
Liverpool,	...	34.1	Prout.
Manchester,	...	36.1	Prout.
Swansea, Wales,	5	36.6	Jenkins.
Bath,	...	30.0	Milner.
Bristol,	...	29.2	Prout.
Truro,	10	44.0	Roy. Inst. Cornwall.
Falmouth,	5	43.7	(Do.)
Dublin,	10	24.6	Trans. Irish Acad.
Cork,	10	40.2	Cork Institution.
Limerick,	...	35.0	Peterman.

EASTERN ENGLAND.

	Yrs.	Inches.	
London,	...	22.2	Daniell.
Chiswick, near London,	10	24.4	Phil. Mag.
Greenwich Observatory,	7	24.3	Observatory Repts.
Cambridge,	...	20.0	Milner.
Boston,	10	24.9	Phil. Mag.
York,	...	23.0	Milner.

The quantity of rain at London is very variably given by different authorities, and Dalton's series is probably too low; the annual mean being fully 22 inches, the quantity given by Daniell. Very much depends upon the altitude and exposure of the point where the observations are taken, and in *Phil. Trans.* for 1792 it is said that the preceding twenty years were inaccurately measured, and that the quantities for those years are "remarkably deficient."

EXTREME QUANTITIES OF RAIN FOR SOME OF THE PRINCIPAL SERIES IN THE UNITED STATES.

[*The Maximum Quantities are first, and the Least Observed during the period in the second line. The date last given applies to the quantity for the year only.*]

STATIONS.	Jan.	Feb.	Mar.	Apl.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year.	Date
Amherst, Mass., 18 yrs.	5.50	6.69	5.73	8.33	8.72	5.18	9.56	9.38	6.38	9.45	7.48	6.41	55.59	1850
1837–1854	0.99	0 99	1.28	0.57	1.91	1.53	1.95	0.99	0.47	1.76	1.90	0.96	34.92	1844
Houlton, Maine, 9½ yrs.	5.99	4.40	2.79	5.32	4.74	6.69	9.40	8.92	4.52	7.84	6.72	4.79	41.91	1840
1836–1845	1.34	0.62	0.12	1.19	1.52	0.46	1.98	0.12	1.10	0.53	1.74	1.55	30.80	1844
Cambridge, Mass., 14 yrs.	7.25	5.70	6.90	9.16	7.68	5.84	4.84	8.74	9.82	7.56	10.42	8.04	54.13	1850
1841–1855	0.72	0.62	1.06	0.34	1.50	0.66	1.41	0.35	1.21	1.26	1.16	2.78	34.74	1844
Providence, R. I., 24 yrs.	6.45	5.73	5.58	7.80	7.28	9.65	7.50	8.38	7.45	9.15	9.08	6.10	53.27	1853
1832–1855	0.60	1.13	0.85	0.67	1.50	0.33	0.30	0.72	0.25	1.16	1.35	1.08	29.51	1846
New Bedford, 42½ yrs.	8.47	7.38	7.49	8.24	7.64	6.58	10.67	9.03	10.72	6.64	8.64	8.66	58.14	1829
1814–1856	0.68	0.81	1.14	1.07	0.51	0.37	0.78	0.21	0.55	0.56	1.33	0.40	30.68	1846
New York, (Ft. Columbus) 19 yrs.	5.57	5.74	8.48	8.80	9.70	8.50	6.01	15.26	12.20	6.61	8.36	8.60	65.51	1837
1836–1854	0.61	0.80	0.70	0.55	0.73	0.76	1.35	1.03	0.48	1.34	1.59	1.00	29.80	1840
Albany, 28 yrs.	7.30	4.39	7.37	5.23	8.47	7.60	8.57	7.51	8.08	8.04	7.29	5.24	50.97	1850
1826–1853	0.76	1.25	0.94	0.74	0.76	1.71	0.70	0.88	0.93	1.34	1.37	0.24	31.79	1852
Rochester, 20 yrs.	3.03	3.71	3.55	4.46	6.12	8.35	6.16	5.27	6.83	6.79	4.70	5.28	39.00	1847
1834–1853	0.11	0.21	0.55	0.50	0.79	1.29	0.94	0.70	0.68	0.56	1.07	0.46	17.84?	1834
Pittsburg, 18 yrs.	3.76	3.53	4.77	9.27	5.83	7.50	7.15	6.56	6.44	4.78	4.27	5.16	47.79	1846
1837–1854	0.35	0.07	1.11	0.83	1.18	1.32	1.26	1.13	1.26	0.60	1.59	1.19	25.62	1839
Philadelphia, 12 yrs.	5.03	4.74	5.47	6.83	6.50	6.60	5.97	9.10	9.51	5.73	7.97	6.26	54.85	1841
1837–41; 1845–51	0.73	1.39	1.50	0.58	1.57	2.03	2.37	1.71	0.25	0.66	2.49	1.04	35.00	1848
Gettysburg, 17 yrs.	6.35	5.57	5.37	5.93	5.78	7.72	5.67	10.88	8.37	7.12	8.48	6.08	52.28	1846
1839–1855	0.63	1.20	0.84	0.62	1.10	0.26	0.93	0.90	0.72	0.83	0.94	1.01	30.19	1845
Baltimore, 19 yrs.	6.10	4.90	6.30	9.10	5.77	9.20	6.89	9.10	10.50	7.35	7.90	8.80	51.70	1839
1836–1854	1.02	0.94	1.70	0.41	1.19	0.60	1.26	0.31	0.50	1.30	1.06	1.50	28.39	1845
Norfolk,[1] 19 yrs.	8.10	5.60	8.50	6.30	7.70	11.10	18.01	14.20	16.40	6.80	9.35	9.60	74 16?	1840
1836–1854	0.51	1.50	1.20	0.90	0.82	0.56	1.60	0.60	0.76	0.50	1.30	0.91	19.32?	1854
Charleston,[2] 15 yrs.	4.87	7.74	7.47	5.29	5.90	15.84	10.66	12.21	14.66	9.50	5.37	9.68	65.96	1739
1738–1754	0.06	0.80	0.62	0.19	1.82	1.57	1.25	3.76	0.75	0.35	0.68	0.96	36.00	1742
Charleston, (Ft. Moultrie) 12 yrs.	4.97	5.85	10.52	3.80	9.45	8.86	13.25	14.70	11.70	7.55	3.40	6.07	65.31	1847
1843–1854	0.25	0.20	0.25	0.02	0.63	0.78	2.32	2.20	0.29	0.00	0.20	1.08	33.98	1844
Key West, 13 yrs.	4.42	3.67	12.06	2.90	5.35	18.11	6.63	7.50	14.00	14.07	5.75	8.45	59.57	1851
1833–1854[3]	0.05	0.00	0.00	0.02	0.40	0.10	1.10	0.70	3.25	0.40	0.01	0.01	20.48	1838
Fort Brooke, Fla., 16 yrs.	4.55	6.89	7.73	8.82	8.85	13.20	24.52	23.40	12.69	4.80	4.56	7.38	89.86	1840
1840–1855	0.30	0.15	0.05	0.10	0.30	2.05	3.18	4.67	1.33	0.30	0.18	0.50	44.77	1853
Mobile,[4] 15 yrs.	14.90	8.37	16.45	11.51	7.23	16.67	14.56	11.15	11.09	11.87	10.57	13.09	106.57	1853
1841–1854	1.92	1.95	0.77	1.14	0.72	1.56	1.84	2.18	0.15	0.40	1.70	0.73	48.55	1850
New Orleans, 17 yrs.	19.50	9.84	7.88	10.70	8.06	14.07	14.74	8.39	8.92	6.45	8.83	9.44	62.64	1853
1839–1855[5]	0.11	0.73	0.90	0.53	0.45	1.31	0.89	1.37	0.63	0.75	0.11	0.80	39.96	1852
Vicksburg, 15 yrs.	12.10	10.65	8.50	7.15	6.85	6.17	7.99	7.42	6.68	6.23	11.30	9.44	60.28	1843
1840–1854	1.10	0.22	1.84	0.40	0.86	0.96	0.26	0.00	0.60	0.00	0.15	0.50	37.21	1844
Huntsville, Ala., 9 yrs.	10.41	11.45	10.79	12.30	6.53	7.99	8.40	10.25	4.02	5.85	9.12	7.62	67.66	1833
1831–1839	1.52	2.08	1.93	2.77	1.94	1.66	1.66	0.69	0.83	0.00	0.28	1.52	29.07	1839
Fort Gibson, 18 yrs.	7.40	10.42	7.83	12.55	10.13	9.17	8.72	8.18	8.04	9.35	8.15	7.70	55.82	1840
1837–1854	0.10	0.20	0.30	0.50	0.37	1.60	0.64	0.00	0.35	0.52	0.85	0.03	18.84	1838
St. Louis, (Dr. Engelmann,) 19 yrs.	4.66	6.74	7.66	7.68	11.26	17.07	9.44	9.78	5.81	8.74	8.63	10.90	65.36	1848
1837–1855	0.45	0.56	0.79	2.28	2.38	1.47	0.84	0.45	0.30	0.96	1.10	0.71	30.89	1853
Cincinnati, 20 yrs.	6.48	6.45	8.24	8.11	9.01	11.50	8.90	7.20	7.51	9.57	6.66	9.43	65.18	1847
1835–1854[6]	0.45	0.82	0.56	0.55	1.34	1.51	2.05	0.56	0.43	0.13	1.68	0.60	30.62	1839
Detroit, 13 yrs.	4.20	3.68	5.15	4.25	5.68	6.56	7.02	4.35	8.78	6.00	4.35	3.24	33.49	1849
1836–1851[7]	0.61	0.18	0.55	1.55	0.29	1.09	1.20	1.00	1.03	0.36	1.24	0.15	21.51	1845
Fort Brady, 18 yrs.	2.74	2.19	2.51	3.07	4.14	4.26	8.15	6.37	6.30	5.72	4.67	3.24	36.92	1837
1837–1854	0.92	0.32	0.32	0.43	0.47	0.95	1.53	0.41	2.61	1.10	1.35	0.45	21.74	1853
Fort Snelling, 19 yrs.	1.67	1.46	4.11	5.62	6.57	7.59	11.11	9.60	6.55	5.35	3.46	2.34	49.69	1849
1836–1855	0.00	0.01	0.02	0.18	0.57	0.08	1.57	0.89	0.71	0.01	0.10	0.04	15.07	1852
Fort Leavenworth, 19 yrs.	2.90	2.73	3.64	5.53	7.18	15.80	8.08	6.66	7.80	6.05	4.33	3.50	48.12	1844
1836–1855	0.01	0.20	0.15	0.27	0.56	0.52	0.01	0.08	0.30	0.00	0.05	0.00	15.94	1843
Brownsville, Texas, 6 yrs.	4.30	4.83	3.03	2.20	4.10	10.47	7.58	5.00	11.31	7.75	7.47	4.70	56.30	1855
1850–1855	0.00	0.60	0.00	0.00	0.10	0.06	0.00	0.01	0.25	4.10	0.69	0.00	20.76	1850
Albuquerque, N. M., 6 yrs.	0.30	0.56	1.02	0.74	1.19	8.15	2.59	4.06	2.67	1.37	1.35	0.92	..	..
1850–1855	0.00	0.00	0.01	0.00	0.03	0.00	0.07	0.45	0.07	0.00	0.16	0.02	..	..
San Diego, Cal., 6 yrs.	2.40	4.83	2.14	1.82	2.10	0.68	0.07	1.35	0.13	0.19	2.82	4.50	12.06	1854
1850–1855	0.00	0.20	0.34	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.31	7.49	1851
San Francisco,[8] 6 yrs.	6.09	8.41	6.40	5.00	0.69	0.40	0.00	0.05	1.00	2.12	5.50	11.90	25.83	1852
1849–1855	0.58	0.12	1.88	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.30	15.12	1851
Steilacoom, 6 yrs.	15.30	8.40	7.85	12.50	5.81	5.68	1.70	3.93	4.99	6.93	18.41	14.62	69.21	1854
1850–1855	5.10	1.47	2.20	1.00	0.12	0.40	0.00	0.00	1.02	2.40	3.02	2.62	33.31	1850

[1] The extreme measurements at Norfolk (Fort Monroe) are not fully relied upon.

[2] The first series is by Dr. Lining, the second at the military post. Though separated by a century they agree very nearly.

[3] The obs. of W. A. Whitehead included with the Military Register; the years 1839–43, and 1846–49 not included.

[4] 1841 and 1842 by Dr. North at Mobile; the remainder at Mount Vernon Arsenal.

[5] The observations of Dr. Barton included with those of the Military Register.

[6] Record of Prof. Ray completed from observations by John Lea, Esq.

[7] 1847 and 1848 omitted, with the last half of each, 1838, 1846 and 1851.

[8] Record of Dr. Gibbons, and the Military Register commencing Dec. 1849.

MEAN TEMPERATURES FOR SERIES OF YEARS.

It is impossible to give observations for successive years at as many points as would be desirable to represent every part of the United States. The *Transactions* of the Berlin Academy alone contain any such general and complete publication, and the gigantic labors of Professor Dove in their accumulation have been met by great liberality in publication, the successive volumes containing all that could be obtained by him for every part of the earth. Nothing would add so much to the basis of facts for the construction of an American Climatology as this complete publication of all the temperature records which have been taken on this continent.

The details of the first series of 33 years at Cambridge are inaccessible, as also that of Dr. Williams, 1783 to 1788. For the period from 1786 to 1828 Dr. Holyoke's celebrated series is preferred, though Prof. Farrar observed 23 years at Cambridge, 1790 to 1812, with apparent accuracy, and these two records agree very closely. Next there are 20 consecutive years at Boston by Mr. Hall, 1820 to 1839. The U. S. Arsenal at Watertown supplies an interval, which is taken for $4\frac{1}{4}$ years, 1837 to 1841, to compare with others of the same date, and Professor Bond's series at the Astronomical Observatory of Harvard University concludes the period.

The series at Salem is published in full, with a prefatory memoir by Dr. Hale, in the Memoirs of the American Academy for 1838. The hours of observation were "8 or 9; about noon, or 1 p. m ; at sunset; and regularly at 10 p. m." The first 7 years were prepared for publication by Dr. Holyoke; the next 26 years by Dr. Clapp; and the last portion by Dr. Hale. For 3 years, 1793 to 1795, the hour of *sunrise* was observed, and after 1818 "a register night thermometer." Dr. Hale supposed that a considerable reduction of the averages was necessary, but at length assigned $1^{\circ}.7$ of reduction to the mean of each month, making the summary for the year $47^{\circ}.1$. The comparison of various parts of the series is not affected whether the reduction is applied or not, and other records indicate that the annual mean at Salem is very nearly 48°.

At Boston the hours were 7, 2, and 9; at the Arsenal, and at Cambridge Observatory, they were *sunrise*, 9, 3, 9 to 1853; then 7, 2, 9.—The series representing the climate of Boston is complete for 70 years, and with Dr. Winthrop's observations comparisons could be made for 115 years.

The series by Samuel Rodman, Esq., at New Bedford, is at least equal to that of Dr. Holyoke in extent and value; the period being greater than at Salem, and the observations more uniformly taken. For this Mr. Rodman's manuscript has been kindly furnished, to June, 1856. A note to the summary previously given, explains the conditions of observation.

The series at the Military Post of Fort Columbus, New York Harbor, is believed to be more than usually accurate; it correctly represents the city of New York.

At Philadelphia, the first, in 1748 and 1749, are Bartram's observations, from Kalm; those for 1758–9, and 1767–1777 from manuscripts in the possession of the American Philosophical Society. The series 1798 to 1804, is from the manuscript and published records of Dr. John Redman Coxe. For 1822 to 1824 the Military record is taken, the observations being at 7, 2, 9. From 1825 to 1836 the record at the Pennsylvania Hospital is taken as corrected by Dr. Conrad from observations at 7, 1, 6. From 1836 to 1843 Maj. Mordecai's series at Frankfort Arsenal is taken, a portion of which was observed hourly, and the remainder fully corrected. Dr. Conrad's observations at the Pennsylvania Hospital, computed from the daily extremes, conclude the period.

At Baltimore, the succession of years may be made complete by reference to the observations at Washington, or the two points may mutually serve by allowing $1^{\circ}.5$ of difference between them. Dr. Brantz's observations were at a point locally elevated, as were those at the Naval Observatory at Washington; both giving lower mean temperatures than other records at the same cities.

At Charleston, the observations by Dr. Lining were computed from the extremes daily, and the ten years by Dr. Chalmers were so observed, but in those there are certainly errors of computation. The averages for the year are the same, however, for periods separated more than a century.

At Key West 1830, 1831, and 1836 are from the record of W. A. Whitehead, Esq.

At New Orleans the series is irregular, and omissions are supplied from other points in the vicinity; the summer months from 1849 forward were observed at some point of the Gulf coast eastward. Dr. Barton gives mean temperatures lower on each month than these, but the mutual relation of the months and years is here distinctly shown.

CAMBRIDGE, SALEM, BOSTON, WATERTOWN ARSENAL, CAMBRIDGE OBSERVATORY; MASS.

DATE.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1780	..	..	..	..	..	..	75.0°	76.0°	64.0°	51.0°	38.0°	31.0°	..
1781	32 0°	31.0°	37.0°	45.0°	58.0°	65.0°	74.0	72.0	67.0	..	36.0	30.0	..
1782	25.0	27.0	..	..	..	..	..	72.0	65.0	51.0	38.0	33.0	..
1783	27.0	34.0	36.0	52.0	59.0	72.0	72.0	70.0	60.0	50.0	36.0	32.0	..
§1786	24.8	28.6	39.7	40.8	57.1	71.6	71.3	68.9	62 5	55.6	34.7	26.5	48.5°
1787	26.2	24.7	36.1	45.8	55.5	65.3	69.2	70.0	60.5	49.2	41.3	30.7	47.9
1788	22.7	23.2	34.2	45.3	56.2	64.3	72.1	70.6	62.8	49.2	44.3	27.2	47.6
1789	26.1	21.7	34.1	45.3	52.4	68.6	71.6	70.5	61.9	45.5	41.2	33.4	47.7
1790	28.6	25.8	32.5	42.7	55.8	65.9	70.6	67.2	60.8	49.9	37.8	19.4	46.4
1791	26.1	24.6	37.6	47.8	60.4	69.4	72.4	71.2	61.5	46.5	39.1	30.7	48.9
1792	19.2	26.9	39.6	48.3	60.5	65.3	70.9	69.8	59.1	52.8	42.2	26.4	48.4
1793	27.9	29.4	38.6	49.7	62.6	71.8	73.7	72.3	63.8	51.0	40.1	30.3	50.9
1794	27.7	27.3	39.7	48.9	59.5	67.3	73.6	71.9	64.7	48.4	39.6	40.4	50.8
1795	26.0	26.7	36.7	46.7	57.7	67.4	71.7	74 8	65.4	54.0	40.7	34.0	50.2
1796	28.2	28.1	34.6	48.9	56.6	68.0	73.3	72.4	62.9	50.0	37.1	23.8	48 7
1797	23.0	32.9	36.7	45.7	54.0	68.0	75.6	69.6	61.6	49.3	36.1	24.9	48.1
1798	27.1	25.8	36.6	48.0	60.1	68.4	73.4	75.7	64.9	53.1	36.4	23.8	49.4
1799	26.2	25.8	30.0	44.0	57.4	67.8	72.7	73.1	62.1	50.3	41.3	28.5	48.3
1800	26.3	28.3	34.8	50.6	56.6	69.8	70.0	70.8	63.1	52.2	37.8	34.2	50.0
1801	26.5	28.8	38.8	46.8	60.6	67.3	73.2	71.7	66.2	53.4	40.3	31.2	50.4
1802	34.1	27.3	37.2	47.0	53.8	67.4	72 7	72.6	65.7	55.4	42.6	33.2	50.8
1803	28.1	32.6	36.9	47.1	55.0	68.3	72.2	73.1	62.5	53.4	38.3	35.1	50.2
1804	21.5	28.0	34.3	44.1	60.3	67.5	71.9	69.6	63.7	48.9	40.3	26.6	48.3
1805	22.3	30.1	39.8	49.5	58.9	67.3	75.5	72.4	65.8	49.4	40.2	37.8	50.8
1806	26.7	31.4	31.3	41.1	55.8	66.7	69.9	68.6	61.9	51.2	40.2	30.4	48.0
1807	23.2	25.3	32.5	45.6	55.0	65.7	72.5	70.6	60.6	51.7	38.5	36.1	48.1
1808	25.9	31.0	38.9	47.1	55.2	67.2	72.1	68.7	64.2	49.6	41.5	32.2	49.5
1809	23.0	23.9	32.4	47.0	56.3	66.2	68.1	68.9	60.9	53.0	35.0	35.2	47.9
1810	25.8	29.9	33.9	47.8	58.8	67.2	70.3	69.7	64.1	51.0	39.4	29.8	49.0
1811	26.3	28.1	39.3	46.3	58.3	68.1	72.8	70.9	64.3	55.1	41.4	29.8	50.1
1812	22.2	25.2	29.4	43.9	49.6	62.5	67.6	66.9	58.4	50.6	37.9	28.9	45.3
1813	23.1	27.1	29.7	46.4	53.6	65.0	69.8	71.6	65.3	49.8	41.8	29.0	47.7
1814	23.9	29.6	34.3	48.7	58.5	63.6	71.7	68.5	61.7	51.1	40.8	26.6	48.3
1815	23.5	23.4	36.1	43.0	53.5	66.7	74.9	66.5	61.9	49.7	42.3	29.5	47.6
1816	25.2	28.0	30.7	45.3	53.8	61.8	66.8	67.7	59.1	51.6	43.9	31.3	47.1
1817	24.0	20.0	32.2	44.0	55.9	63.4	71.3	68.9	63.4	49.7	41.7	32.1	47.3
1818	24.4	19.8	35.8	41.1	55.8	69.7	74.3	70.6	61.1	52.6	44.2	26.2	48.0
1819	31.1	33.9	30 3	43.9	56.4	70.1	73.8	71.9	66.7	52.7	42.7	29.6	50.7
1820	22.2	30.1	35.0	46.1	56.3	68.3	76.8	71.2	66.4	50.8	37.7	25.0	48.7
1821	19.4	31.2	33.6	44.1	56.0	67.9	70.0	72.5	62.8	51.1	40.9	27.6	48.1
1822	22.0	26.7	39.1	44.3	60.8	67.3	73.4	70.8	67.3	52.9	42.1	30.8	49.8
1823	26.4	23.3	33.2	46.9	54.2	66.2	72.0	71.4	59.4	49.9	36.1	31.7	47.6
1824	30.7	28.9	35.2	47.7	54.9	65.8	72.1	68.2	63.3	51.7	38.5	33.8	49.2
1825	28.5	30.7	40.3	49.6	58.4	71.0	77.7	70.3	60.7	52.8	39.6	32.0	51.0
1826	27.8	30.3	35.7	43.9	63.5	67.2	75.9	70.3	64.8	51.7	40.4	31.8	50.3
1827	22.2	29.0	36.9	49.8	56.8	65.8	71.6	68.8	62.4	53.8	33.8	30.6	48.4
1828	31.1	36.9	37.9	44.1	55.3	69.5	73.2	72.8	63.9	50.8	42.6	35.2	51.3
1820	22.9	31.1	35.3	44.9	55.2	66.4	75.3	70.3	64.7	50.1	37.7	26.5	48.4
1821	20.6	32.5	34.0	43.6	56.0	66.5	68.2	71.5	63.2	50.2	40.6	29.3	48.0
1822	23.3	28.3	38.7	45.1	61.4	66.7	72.9	68.2	66.5	52.2	44.2	30.3	49.8
1823	26.7	22.7	33.6	46.7	53.8	68.1	70.9	70.5	58.8	50.2	36.4	32.5	47.3
1824	30.3	29.3	35.8	47.8	55.1	64.9	71.3	67.2	62.9	51.8	39.8	34.7	49.2
1825	28.7	31.3	40.0	48.8	57.0	69.8	77.6	69.4	60.2	53.1	39.7	32.5	50.7
1826	29.0	30.9	36.6	43.6	63.6	67.9	72.9	69.9	64.5	51.9	40.6	32.3	50.3
1827	22 6	28.9	37.4	50.3	56.9	66.0	71.7	69.0	62.5	53.0	35.0	32.0	48.8
1828	31.9	37.5	37.7	44.2	56.9	70.1	73.6	74.1	64.3	51.1	43.7	36.3	51.8
1829	26.2	23.1	32.3	46.4	59.9	66.5	69.6	69.0	58.3	50.0	40.8	37.4	48.3
1830	25.7	25.9	37.5	48.1	57.1	66.7	72.0	69.9	59.3	52.7	46.7	35.2	49.7
†1831	23.4	24.9	41.3	48.5	59.3	71.5	73.1	72.4	63.1	53.7	40.8	19.1	49.3
1832	27.4	28.7	37.0	42.0	53.1	64.5	68.0	69.8	61.2	52 2	41.8	31.3	48.1
1833	31.2	25.4	33.0	48.7	58.9	63.2	72.1	67.0	62.3	50.6	38.3	31.8	48.5
1834	24.8	34.2	37.5	46.9	53.4	63.8	74.0	68.3	62.9	49.0	38.5	28.6	48.5
1835	27.3	25.4	32.8	43.8	55.3	65.4	71.7	68.7	57.9	53.5	40.2	23.4	47.1
1836	26.9	20.9	31.8	43.7	55.4	58.9	69.2	65.1	60.5	45.2	36.8	29.5	45.3
1837	21.7	25.7	31.9	44.7	52.9	63.7	68.4	65.3	59.0	48.0	39.3	28.9	45.8
1838	33.3	19.3	35.8	41.7	54.8	68.9	74.2	69.1	61.0	47.7	35.6	26.7	47.3
1839	27.1	29.2	35.7	47.5	56.4	62.5	72.5	68.9	62.2	51.4	37.6	31.9	48.6
1837	21.5	25.9	31.5	44.2	53.7	63.7	67.7	65.1	59.1	49.1	40.1	29.3	45.9
1838	32.9	19.0	35 6	41.3	54.6	68.2	74.0	70.0	62.2	47.5	35.7	26.7	47.3
1839	27.2	28.1	36.4	47.9	55.5	61.3	71.8	69.0	63.2	52.5	37.6	30.6	48.4
1840	19.2	33.4	37.1	47.6	56.7	66.1	72.5	71.1	60.8	51.4	38.7	27.2	48.5
§1841	30.8	26.4	35.3	41.1	53.1	67.4	71.1	68.5	62.3	44.5	36.3	30.0	46.6
1842	27.2	31.6	37.4	44.4	51.7	62.6	72.6	67.5	58 2	47.9	34.8	23.5	46.6
1843	29.6	16.3	25.4	43.5	54.5	64.2	69.2	69.9	60.5	47.5	36.8	26.9	45.4
1844	15.3	24.5	33.8	48.4	57.3	65.1	68.1	67.7	64.0	47.0	34 3	26.9	46.0
1845	27.2	27.6	36.2	43.8	56.6	68.1	72.1	71.8	60.2	51.7	44.3	25.6	48.8
1846	27.4	21.3	38.2	49.5	55.8	65.0	71.5	70.2	66.7	51.2	43.2	27.4	48.9
1847	26.4	25.8	30.8	42.0	53.3	64.7	73.0	68.1	60.9	47.6	44.1	34.7	47.6
1848	29.1	24.7	32.2	45.5	57.8	64.8	70.2	69.5	58.6	49.8	36.2	34.3	47.7
1849	21.0	18.4	35.8	43.5	52.5	67.7	71.6	69.2	60.0	49.2	45.0	28.9	46.9
1850	27.2	29.3	32.6	42.4	51.4	67.2	71.5	66.9	60.9	51.4	41.0	25.2	47.3
1851	25.5	29.9	36.2	44.5	55.5	64.7	71.4	68.0	61.1	52.9	34.8	22.8	47.3
1852	20.8	27.4	32.9	41.0	56.7	67.4	72.4	66.6	62.1	50.4	38.3	35.0	47.6
1853	25.8	29.2	35.8	45.1	56.3	66.8	70.5	67.5	61.2	47.7	39.5	26.4	47.7
1854	23.9	23.4	32.1	42.6	58.5	65.6	74.3	68.4	61.5	52.5	41.2	24.3	47.4
1855	28.4	20.2	32.3	44.1	53.4	65.5	72.2	67.3	61.4	51.5	40.0	28.6	47.1

NEW BEDFORD, MASS., Samuel Rodman.

DATE.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1813	27.2°	29.8°	32.9°	45.7°	52.4°	63.6°	69.1°	70.3°	65.3°	51.8°	44.0°	31.4°	48.6°
1814	26.8	31.9	34.8	47.1	59.8	62.3	68.2	67.6	61.9	52.1	42.7	29.5	48.7
1815	26.5	25.1	37.7	42.8	52.1	63.5	70.4	66.2	61.3	51.3	44.5	30.6	47.7
1816	26.2	30.2	33.5	43.1	51.8	58.8	63.6	66.0	58.5	52.8	44.7	34.3	47.0
1817	26.4	22.5	32.7	44.7	53.6	61.2	68.2	69.1	62.6	51.3	44.3	35.0	47.6
1818	28.4	24.1	36.4	41.8	54.5	66.7	71.8	67.7	61.7	53.0	45.2	28.6	48.3
1819	32.3	33.6	31.7	43.6	52.4	66.7	70.5	70.5	66.0	52.4	45.3	32.2	49.7
1820	24.6	33.0	35.9	44.8	53.9	65.6	42.6	70.8	63.8	52.2	40.6	29.4	48.9
1821	22.7	35.5	34.5	42.0	54.9	64.2	67.5	70.4	64.1	52.1	42.1	32.0	48.3
1822	25.5	29.8	38.8	46.0	58.5	65.7	72.4	68.1	66.8	54.5	45.2	33.0	50.4
1823	29.7	24.9	34.7	45.5	53.3	62.8	68.3	69.7	59.4	51.0	38.6	35.5	47.8
1824	33.1	31.2	35.9	47.3	54.3	63.8	70.2	66.8	62.4	53.1	41.8	36.7	49.7
1825	31.4	32 7	40.2	47.2	56.3	68.5	74.4	69.6	61.1	54.7	43.2	35.4	51.2
1826	32.0	34.0	38.5	43.1	61.4	64.6	71.3	70.1	64.7	54.3	43.4	34.9	51.0
1827	25.9	31.8	37.8	48.9	54.6	63.5	70.1	68.1	62.7	54.4	37.0	34.8	49.1
1828	34.1	37.5	38.0	42.8	54.4	66.2	70.3	70.5	63.3	50.8	44.0	37.4	50.8
1829	27.7	24.0	31.9	44.3	55.7	62.4	66.4	67.0	57.2	49.9	42.1	39.5	47.4
1830	28.5	27.5	37.3	46.8	55.6	64.7	71.3	68.8	60.1	53.4	48.2	36.4	49.9
1831	24.3	25.6	39.8	46.8	57.8	69.4	70.9	72.1	63.7	54.9	41.0	21.0	49.0
1832	30.1	29.3	35.4	40.4	51.6	61.1	66.4	68.6	60.9	53.4	43.5	32.9	47.8
1833	32.3	26.8	33.7	47.7	57.8	62.2	68.6	66.1	61.5	52.6	39.6	33.4	48.5
1834	26.3	34.8	36.9	46.8	52.5	62.9	70.9	68.0	63.0	50.0	39.7	34.0	48.5
1835	28.8	26.2	32.6	42.8	53.9	63.0	69.0	67.0	57.9	54.6	41.7	26.4	47.0
1836	25.7	22.2	32.3	41.9	53.7	60.0	68.1	63.9	60.5	46.1	37.3	31.3	45.2
1837	23.9	27.1	32.0	43.0	52.8	62.1	66.5	64.9	58 4	49.8	41.9	30.4	46.1
1838	34.2	21.4	35.9	41.1	52.2	66.1	73.1	69.3	61.3	48.8	37.4	28.5	47.4
1839	28.4	30.1	36.1	44.8	55.5	61.2	69.6	65.8	61.3	51.8	39.1	32.9	48.1
1840	21.5	34.2	36.4	46.3	52.5	62.8	68.7	69.7	59.6	52.4	40.1	29.6	47.8
1841	31.7	26.3	35.7	41.5	51.0	64.0	66.8	66.8	61.9	45.8	39.1	33.2	47.0
1842	31.4	34.3	39.5	44.1	50.6	60.3	68.2	66.8	58.8	50.5	38.0	29.0	47.5
1843	34.3	22.3	27.6	43.8	53.3	64.2	67.7	69.6	62.0	50.5	37.7	31.9	47.1
1844	21.4	29.5	36.3	48.8	56.7	63.6	67.4	67.7	61.8	52.1	41.4	33.8	48.4
1845	32.0	29.1	37.8	44.4	53.6	63.7	69.6	70.5	61.1	51.4	46.3	28.9	49.0
1846	30.0	25.2	38.7	46.9	55.0	62.0	69.0	68.5	66.4	51.6	46.1	31.1	49.2
1847	30.9	29.9	32.9	42.5	52.9	64.0	69.6	67.8	62.4	51.1	45.9	38.4	49.0
1848	33.0	28.1	35.0	45.8	55.6	65.1	67.9	68.5	60.2	52.1	39.2	38.8	49.1
1849	25.4	24.1	37.3	44.2	53.7	65.2	69.2	68.9	61.7	51.1	47.9	32.3	48.4
1850	32.0	33.2	34.7	41.3	51.5	61.9	70.2	67.3	61.5	53.6	42.4	29.6	48.3
1851	29.7	31.3	37.5	45.3	54.2	62.9	68.9	66.3	61.0	54.6	38.3	25.8	48.0
1852	25.0	29.0	34.7	41.6	54.7	64.9	70.5	66.4	61.7	52.6	39.7	38.3	48.3
1853	29.5	31.9	38.0	44.9	55.2	64.8	69.7	68.7	61.9	51.0	43.6	30.5	49.1
1854	28.8	26.6	34.0	43.3	57.2	65.3	72.4	70.9	62.1	56.3	43.7	28.3	49.1
1855	32.1	23.4	33.8	44.5	53.8	64.5	69.7	66.3	61.2	54.2	43.0	34.2	48.4
1856	20.9	22.6	29.1	45.3	52.8	65.6	..	..	..	..	..	..	..

NEW YORK, Fort Columbus, Governor's Island.

1821	..	..	..	..	..	..	..	..	..	53.7	43.4	33.3	..
1822	26.2	29.8	42.1	52.4	63.4	70.6	78.4	74.6	70.9	59.1	48.4	34.5	54.2
1823	31.2	25.3	36.4	49.6	58.9	68.9	74.9	73.4	64.1	51.8	38.2	34.7	50.5
1824	35.3	31.3	37.6	49.9	58.0	68.3	73.6	70.4	64.1	55.1	42.7	38.5	52.1
1825	32.7	32.6	43.7	51.3	62.5	74.6	81.3	74.0	67.4	57.1	43.9	31.7	54.4
1826	28.9	31.3	37.7	43.3	64.9	69.8	75.9	75.9	68.8	56.5	43.7	33.1	52.5
1827	24.0	31.9	39.3	52.1	59.5	68.6	75.6	74.3	67.1	55.9	39.7	33.2	51.8
1828	33.6	41.3	40.7	45.3	60.1	72.2	74.7	76.5	66.8	53.4	44.9	38.7	54.0
1829	27.1	25.4	37.9	52.3	63.8	71.1	73.7	75.0	64.1	54.8	43.9	41.3	52.5
1830	31.7	31.9	41.1	52.9	60.3	70.4	78.7	77.1	67.1	58.7	51.1	36.9	54.8
1831	25.7	26.3	42.0	50.0	61.2	74.1	76.4	76.4	66.9	55.4	43.3	22.2	51.6
1832	28.5	32.3	39.0	48.3	56.1	67.1	73.3	73.2	65.4	54.1	44.7	36.4	51.5
1833	35.1	30.9	35.9	51.3	60.7	66.1	74.7	70.6	64.8	52.2	41.5	34.6	51.5
1834	28.3	37.2	39.6	48.5	56.5	66.7	76.2	71.8	64.2	51.6	41.0	30.7	51.0
1835	29.4	27.2	35.6	45.8	58.4	67.1	72.5	69.8	60.7	56.4	43.8	28.4	49.6
1836	27.8	21.5	32.2	44.3	58.0	62.3	73.0	67.9	64.0	45.8	38.7	31.2	47.6
1837	26.3	29.8	34.9	46.0	55.3	64.5	69.5	68.6	62.2	52.9	44.0	35.6	49.1
1838	34.5	23.3	37.8	44.2	56.2	70.4	77.2	74.7	65.4	51.7	40.0	29.1	50.3
1839	30.5	31.9	38.6	49.8	57.8	63.4	73.0	70.8	66.7	56.3	39.9	35.6	51.2
1840	23.8	34.8	40.3	51.5	58.0	67.0	72.3	73.3	64.0	55.2	43.6	30.3	51.2
1841	30.8	28.1	37.4	46.0	56.5	69.1	73.9	73.4	68.6	51.8	44.9	33.8	51.2
1842	33.7	38 1	44.6	51.5	58.5	67.2	74.4	72.9	67.1	51.7	39.2	32.1	53.4
1843	36.5	25.7	30.3	47.3	59.1	71.2	74.1	74.3	68.0	53.7	40.5	36.1	51.4
1844	25.7	29.7	38.8	53.5	63.3	69.2	74.5	72.9	65.8	53.5	43.3	34.0	52.0
1845	35.0	31.9	42.1	50.8	60.5	71.3	76 6	76.0	65.5	55.3	45.7	38.3	53.3
1846	31.4	27.4	39.3	50.3	60.4	67.4	72.2	73.2	69.7	54.0	48.1	33.9	52.3
1847	32.4	31.6	36.0	49.5	59.5	70.8	75.6	72.3	64.7	51.4	46.0	37.9	52.3
1848	33.8	31.2	36.1	50.1	61.4	69.1	74.3	73.5	63.4	54.1	39.7	39.3	52.3
1849	25.8	24.7	37.8	47.5	55.0	69.5	72.8	72.3	64.3	52.6	48.2	32.1	50.2
1850	32.8	33.4	36.2	44.1	54.4	68.6	75.1	71.0	64.3	53.8	45.2	33.2	50.9
1851	32.1	33.7	39.7	49.1	58.2	68.4	75.6	74.0	67.9	57.3	42.2	37.4	52.1
1852	24.3	30.7	36.7	43.7	60.3	69.7	76.6	73.3	63.8	55.6	41.6	40.4	51.4
1853	32.1	33.5	39.6	48.1	60.2	71.2	72.8	73.5	66.4	52.0	44.3	33.1	52.2
1854	28.7	28.2	36.2	45.1	59.9	68.5	75.9	72.9	66.4	55.7	43.7	27.5	50.7

PHILADELPHIA: BALTIMORE; DR. BRANTZ; FORT McHENRY.

DATE.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1748	..	..	..	..	..	..	..	..	..	64.0°	54.7°	49.5°	..
1749	33.5°	40.0°	50.0°	62.0°	75.0°	81.0°	87.5°	85.0°	80.5°	..	..	..	..
§1758	37.2	32.2	38.6	53.3	63.5	72.1	75.7	71.3	64.0	56.7	44.0	34.5	53.6°
1759	30.0	38.0	41.4	49.4	52.4	71.6	73.0	69.7	65.2	55.3	46.4	30.4	52.7
§1767	31.7	32.5	41.0	51.0	61.6	71.2	74.0	75.5	64.5	54.0	46.7	35.3	53 2
1768	28.0	46.0 ?	39.5	46.0	59.0	68.6	71.5	65.7	64.0	50.0	42.0	37.7	51.5
1769	33.0	32.0	42.0	50.0	57.0	68.0	77.0	74.0	64.0	55.0	38.0	32.0	52.0
1770	30.5	37.5	38.5	48.5	57.5	70.0	73.5	71.5	64.0	52.5	46.5	33.5	52.0
1771	36.0	29.0	41.0	53.0	58.0	67.0	71.0	73.0	63.0	53.0	48.0	30.0	51.8
1772	32.5	40.5	30. ?	51.0	56.0	67.0	75.0	77.5	64.0	55.5	45.5	36.5	52.5
1773	32.6	33.7	42.1	52.2	62.7	73.4	79.6	76.0	63.9	58.2	42 2	39 9	54.7
1774	27.0	32.4	43.1	54.6	60.1	67.8	72.8	73.7	63.7	59.3	44.1	36.4	52.9
1775	35.6	41.2	45.3	51.4	65.8	68.3	75.1	72.8	65.6	54 6	41.4	35.7	54.4
1776	32.7	34.2	42.2	51.0	59.9	69.9	74.2	72.8	67.3	55.9	46.3	35.3	53.4
1777	31.0	31.6	40.3	52.2	57.1	70.4	70.6	75 9	59.2	50.0	39.5	33.7	51.0
§1798	33.1	32.3	43.2	53.0	65.7	74.1	76.4	81.6	67.8	58.2	41 1	31.5	54.9
1799	33.7	32.9	38.8	54.2	61.1	71.9	76.2	74.5	67.2	55.0	46.4	33.7	53.1
1800	31.8	31.4	38.7	55.9	61.3	71.0	76.2	73.4	66.6	54.9	40 7	36.8	53.4
1801	31.2	34.5	44.4	49.0	64.6	70.9	76.4	72.8	69.1	56.5	42.0	35.7	53 3
1802	40.8	34 5	42.3	52.9	59.4	71.8	74.7	74.5	67.2	59.9	45 6	33.3	54.9
1803	32.9	36.3	41.9	54.2	58.9	73.0	78.0	75.7	65.9	57.9	43.2	40.6	54 1
1804	29.6	34.0	38.7	50.9	63.8	70.3	76.9	76.5	72.8	57.3	46.9	32.6	54.5
§1822	26.3	30.5	43.4	52.2	65.3	71.2	75.3	71.7	67.1	57.1	47.7	32.5	53.3
1823	31.9	26.6	39.1	55.8	63.8	75.2	82.2	78.8	73.2	58.3	42.4	35.1	55.2
1824	35.1	32.7	38.3	48.5	63.1	75.2	80.9	75.2	73.4	56.1	46.3	39.2	56.4
§1825	33.5	35.5	44.8	51.7	62.0	75.0	79.3	70.0	62.5	54.0	41.0	34.0	53.5
1826	34.0	35.5	39.5	48.5	72.0	74.0	73.0	73.0	67.0	55 0	42.0	34.0	53.9
1827	27.0	35.0	42.0	55.0	62.0	71.0	76.0	69.0	63.0	52.0	39.0	35.0	52.1
1828	37.0	41.5	45.0	47.0	66.0	77.0	75.0	76.0	65.0	54.0	46.5	39.0	55.7
1829	30.0	25.0	37.0	53.0	64.0	73.0	75.0	75.0	60.0	55.0	42.0	42.0	52.6
1830	30.0	31.5	41.0	54.5	64.0	72.0	79.5	75.0	67.0	57.0	50.0	37.0	54.9
1831	27.0	28.0	44.5	54.0	66.0	77.0	78.0	77.0	69.0	56.0	43.0	25.0	53.7
1832	33.0	36.0	44.0	51.0	62.0	71.0	74.0	74.0	63.0	55.0	45 5	38.0	53.9
1833	36.0	35.5	40.5	56.0	63.0	65.0	76.0	72.0	66 0	55.0	43 0	37.0	53.7
1834	29.5	42.0	44.5	54.5	64.5	69.0	79.0	75.0	66.0	53.0	44.0	37.0	54.6
1835	32.0	28.0	40.0	53.0	64.5	71.0	76.0	74.0	65.0	60.0	47.0	31.0	53.6
§1836	27.7	22.7	33.5	48.3	61.5	64.6	73.5	68.3	67.4	48.3	40.8	32.4	49.1
1837	27.4	31.8	38.8	48.0	59.5	67.6	72.4	71.1	62.5	54.4	45.8	35.3	51.2
1838	36.8	24.6	40.7	46.1	57.9	73.4	80.0	77.1	66.3	52 6	42.2	31.0	52.4
1839	31.4	35.1	43.6	55.2	64.3	67.9	76.7	71.6	65.5	57.7	41.3	36.1	53.9
1840	27.2	40.3	45.1	56.2	62.3	68.6	72.8	73.8	62.1	56.2	45.4	31.8	53.5
1841	34.1	31.9	44.1	49.7	59.9	73.8	76.3	74.6	68.1	50.0	41.8	35.2	53.3
1842	34.8	39.1	47.6	53.4	60.5	68.9	76.6	73.3	68.1	58.5	39.7	32.2	54.4
1843	39.5	29.4	32.4	51.4	59.9	70.6	75.2	74.3	68.9	54 0	42.3	35.7	52.8
§1844	27.0	32.0	43.0	56.5	65.5	69.5	75 0	73.5	66.5	53.3	43.5	34 7	53.3
1845	37.0	34.5	44.8	52.0	59.8	71.5	76.0	74.5	65.5	55.8	45.5	28.3	53.8
1846	33.3	29.5	42.7	53.2	64.0	68.8	74.5	74.8	70.8	55.3	49.5	35.8	54.4
1847	32.3	33.2	38.7	51.2	61.8	70.5	76.5	73 5	66.0	54.0	48.3	39.5	53.8
1848	36.7	23.6	39.4	54.4	65.8	73.4	74.8	74.5	64.5	56.2	41.0	43.2	54.8
1849	29.0	27.5	42.5	50 6	58.4	73.5	74.7	74.4	64.4	55.3	51.5	34.4	53 1
1850	35 8	37.1	39.5	48.1	57.7	71.9	77.4	73.0	66.9	56.0	48.0	36.5	54.0
1851	35.2	39.8	43.5	52.0	62.6	70.4	76.8	72.4	67.4	56.6	41.8	30.0	54.7
1852	27.5	34.1	40.7	46.6	63.3	71.8	77.0	72.2	64.8	58.2	43.1	41.9	53.6
1853	33.1	37.3	43.1	52.4	63.5	73.8	75.5	74 6	68.5	53.5	47.9	35.0	54.9
1854	32.2	34.5	43.0	51.2	64.7	71.7	78 7	75.8	69.5	58.7	45.5	31.0	54.7
1855	35.4	27.6	39.0	52.2	61.5	70.2	78.5	73.0	67.6	53.9	48.0	36.7	53.6
1856	24.1	26.1	32.8	53.4	60.0	74.4	79.7	72.8	67.3	55.6	45.4	32.7	52 0
1817	28.8	27.3	40.5	58.3	59.0	69.0	74.7	71.7	65.0	52.3	46.7	34.0	52.3
1818	31.0	28.0	29.7	46.5	57.0	71.0	76.3	73.0	63.0	51.7	45.0	29.0	50.1
1819	36.2	33.5	36.7	50.5	62.3	72.7	75.0	76.0	68.0	51.7	46.7	33.7	53.6
1820	26.0	40.0	41.7	52.7	56.1	69.2	74.6	74.3	66.7	50 0	39.0	32.5	51.9
1821	24.1	37.3	38.4	45.4	59.8	73.7	72.5	78.0	69.0	54.0	43.3	34.0	52.5
1822	27.0	33.5	44.5	55.5	66.7	72.5	76.7	76.5	70.0	59.3	49.3	35.3	55.6
1823	35.3	29.3	41.5	55.7	63.3	69.3	76.0	75.5	66.5	53.7	40.7	36.7	53.6
1824	39.0	34.7	41.0	51.8	60.7	69.5	76.0	72.0	64.8	56.5	44.5	40.3	54.2
§1835	31.8	29.1	41.0	49.0	63.9	71.2	75.5	72.4	61.8	58.4	48.4	33.3	53.0
1836	33 8	26.0	33.8	51.5	63.4	66.8	74.7	70.0	68.5	48.2	41.6	33.5	51.0
1837	28.8	34.1	40.8	49.1	62.2	69.9	74.7	73.8	64.5	56.3	46.7	36.3	53.1
1838	37.3	26.8	42.6	58.3	59.3	74.4	80.5	77.4	67.6	51.3	40.7	31.1	53.1
1839	22.4	34.6	43.3	56.4	66.2	70.0	77.1	72.9	67.1	60.1	40.2	34.3	54.5
1840	24.2	38.7	45.2	54.2	61.5	71.1	73.8	74.4	63.5	55.7	43.7	29.9	52.9
1841	30.4	31.8	40.3	47.4	55.7	73 0	76.4	74.1	70.6	49.3	42.1	35.1	52.1
1842	36.4	38.1	47.9	54.2	59.6	69.0	75.4	73.4	68.1	54.4	38.9	32.7	54.0
1843	38.4	28.1	30.1	50.3	61.0	72.6	75.7	76.3	71.1	54.4	41.9	35.2	52.9
1844	29.2	32.1	41.9	55.9	66.4	69.3	77.3	74.1	66.6	52.9	41.1	33.2	53.3
1845	36.8	34.1	44.1	54.5	60.6	71.8	76.1	..	..	..	..	..	..
1846	32.3	29.6	42 0	53.0	64.8	68.1	74.3	74.2	70.0	54.3	47.3	34.8	53.6
1847	30.7	32.5	38.0	55.7	64.2	70.0	77.6	75.3	68.3	55.8	49.2	37.9	54.6
1848	37.5	36.2	40.7	56.9	67.8	74.9	75.2	76.2	65.2	57.6	42.2	43.9	56.2
1849	31.9	30.9	44.4	52.0	61.2	75.2	76.2	75.4	67.9	57.1	53.5	37.1	55.2
1850	38.2	39.8	42.7	50 6	61.2	74.6	78.5	73.9	67.9	58.2	51.3	40.4	56.4
1851	37.3	39.5	47.1	54 7	64 8	71.4	78.3	73.6	69.4	58.9	46.6	32.6	56.2
1852	28.0	35.8	42.9	47.9	63.2	70.1	74.8	76.0	65.8	58.2	43.0	40.5	53.9
1853	32.3	36.7	42.7	53.2	64.3	74.5	76 0	75.1	69.8	54.1	48.6	36.6	55.3
1854	33.6	36.5	44.4	49.0	64.3	72.0	78.3	75.4	71.3	58.1	50.5	33.7	55.6

WASHINGTON—Comr. Meigs; Rev. Robt. Little; Surg. Brereton; Lt. Gillis.

DATE.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1820	29.2°	41.9°	46.0°	56.8°	63.2°	72.3°	78.8°	75.7°	67.4°	51.6°	42.3°	29.2°	54.5°
1821	27.3	44.1	42.3	51.3	66.1	75.5	74.6	79.4	72.1	57.1	42 2	32.6	55.4
§1825	35.4	39.1	48.8	56.4	64.9	76.3	79.3	75.7	67.5	60.1	44.6	36.1	56.2
1826	35.6	41.3	49.0	53.3	73.4	76.5	77.4	76.2	72.3	58.7	45.8	36.3	58.0
1827	30.2	42.6	47.4	59.9	66.2	74.3	79.9	78.4	70.1	58.4	44.8	41.6	57.8
1828	41.1	47.2	47.5	50.4	66.9	79.3	78.1	79.1	67.4	54.8	47.3	41.7	58.4
1829	32.7	28.6	39.6	54.3	65.5	73.6	74.8	73.9	64.3	55.8	42.7	44.3	54.2
1830	33.8	33.7	46.3	56.3	65.1	73.5	81.1	77.9	69.3	58.6	52.4	37.3	57.1
1831	26.8	29.3	46.8	55.1	63.3	73.9	75.0	74.8	67.4	56.0	42.1	25.4	53.0
1832	32.0	37.1	44.9	..	..	..	..	..	..	..	..	..	..
1833	35.6	36.6	41.6	58.2	70.0	71.3	77.6	74.5	68.6	53.8	43.3	37.5	55.7
1834	29.8	43.2	47.3	55.8	62.8	72.4	80.5	77.2	66.4	53.3	43.8	36.5	55.8
1835	30.1	29.0	41.4	53.4	65.5	75.1	78.0	76.0	62.4	59.8	49.3	33.6	53.6
§1838	..	..	..	..	..	..	..	..	..	..	40.1	30.2	..
1839	31.5	35.8	43.6	56.7	65.7	68.3	74.8	70.3	65.5	58.7	39.2	34.2	53.7
1840	23.9	39.6	45.3	56.4	63.8	70.9	75.3	75.5	62.9	56.0	43.2	30.3	53.6
1841	32.8	32.0	41.7	49.2	59.4	75.0	75.2	72.1	68.2	49.2	43.4	36.1	52.9
1842	36.7	39.3	50.6	56.3	61.5	71.6	..	..	..	..	..	..	..

CHARLESTON, S. C.; Dr. Lining, and FORT MOULTRIE.

DATE.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1738	56.5	54.0	69.0	70.0	74.5	82.0	81.0	78.5	73.5	62.0	54.0	51.5	66.4
1739	49.0	52.0	62.0	67.0	75.0	77.5	78.5	78.5	69.5	64.0	54.0	56.0	65.2
1740	46.0	54.5	58.5	69.5	74.0	78.5	81.0	77.5	75.0	59.5	53.0	44.5	64.3
1742	52.0	48.5	56.5	72.0	74.5	77.5	82.5	81.0	72.5	62.0	49.5	52.5	65.1
1750	33.?	57.0	63.0	65.0	73.0	83.0	75.?	80.0	77.0	67.0	55.0	53.0	65.0
1751	47.0	54.0	62.0	72.0	76.0	83.0	80.0	78.0	70.5	64.0	60.0	54.0	66.7
1752	44.0	58.0	64.0	67.0	74.0	79.0	85.0	78.0	72.0	69.0	65.0	53.0	67.3
1753	53.0	58.0	60.0	65.0	74.0	79.0	78.0	80.0	75.0	69.0	55.0	55.0	66.8
1754	56.0	57.0	65.0	64.0	77.0	81.0	75.0	81.0	76.0	70.0	56.0	56.?	67.8
1755	51.0	48.0	56.0	63.0	71.0	78.0	79.0	77.0	74.0	63.0	54.0	49.0	63.6
1756	55.0	60.0	62.0	63.0	73.0	76.0	84.0	78.0	76.0	66.0	59.0	52.0	67.0
1757	47.0	52.0	61.0	65.0	72.0	77.0	78.0	79.0	75.0	67.0	61.0	55.0	65.7
1758	54.0	51.0	51.?	62.0	70.0	79.0	81.0	80.0	73.0	67.0	61.0	42.0	64.3
1759	44.0	49.0	53.0	63.0	71.0	83.0	86.0	83.0	75.0	65.0	60.0	49.0	65.1
§1823	48.5	43.1	57.1	65.4	75.1	76.0	81.2	79.8	76.4	66.3	56.8	50.9	64.7
1824	52.9	49.4	60.9	64.6	74.7	79.7	82.8	80.1	75.9	68.4	58.3	54.7	64.9
1825	50.3	52.8	61.4	62.6	72.9	79.3	82.1	83.6	77.4	70.9	..	..	..
1826	..	..	..	69.3	73.8	81.1	81.6	81.0	72.0	62.8	54.1	..	..
1827	44.9	59.9	62.4	69.1	73.7	77.2	83.3	80.7	76.7	..	..	..	..
1828	61.5	64.7	64.0	65.1	77.3	86.2	82.7	82.7	78.2	68.6	62.9	59.7	71.1
1829	51.4	46.4	53.6	63.7	66.2	82 8	84.1	84.3	77.8	..	..	..	..
1830	55.8	54.5	63.2	67.3	74.9	79.4	83.2	82.5	81.5	74.2	68.8	56.5	70.2
1831	45.6	48.4	59.8	68.6	71.8	79.6	80.4	81.4	78.2	71.7	63.3	41.6	65.9
1832	48.7	57.3	58.0	64.1	72.9	76.9	79.9	80.0	76.0	67.6	59.2	54.4	66.3
1833	53.2	55.3	57.1	64.3	74.1	77.8	81.3	79.4	77.4	68.1	56.2	50.3	66.1
1834	49.2	57.9	58.2	63.8	71.3	80.7	82.4	79.7	76.5	68.6	59.4	53.1	66.7
1835	46.8	40.1	51.7	61.9	73.7	79.7	79.9	80.0	72.9	67.5	64.5	51.5	64.2
1840	47.9	57.8	61.4	67.2	73.4	77.4	79.3	79.8	73.0	67.3	57.5	49.8	66.0
1841	52.8	48.9	56.3	63.7	69.5	77.0	82.8	81.0	76.7	63.2	61.3	50.2	63.2
1842	53.2	53.4	63.3	66.8	71.8	77.0	78.0	71.1	76.2	66.3	53.5	49.3	65.0
1843	53.7	48.7	48.8	64.7	71.6	78.1	81.5	80.5	80.8	67.3	59.6	53.4	65.7
1844	50.1	51.7	58.1	66.9	76.0	79.8	83.3	81.5	75.1	66.6	61.9	52.7	67.0
1845	54.8	53.1	59.2	68.9	72.4	80.7	82.8	80.5	73.2	67.3	57.6	44.6	66.2
1846	50.6	51.6	58.6	65.9	74.4	79.3	80.6	82.8	78.9	..	61.5	53.4	..
1847	52.7	53.8	54.4	66.6	69.3	80.0	81.1	81.0	76.5	66.7	60.5	53.8	66.4
1848	50.0	50.2	59.5	66.1	..	79.5	81.7	82.7	77.1	64.3	50.2	61.7	..
1849	49.5	49.0	58.7	64.7	72.6	81.3	78.9	81.2	75.3	67.9	60.9	54.2	66.2
1850	54.9	50.7	56.2	62.5	71.8	76.8	83.8	83.3	77.8	66.3	59.8	55.6	66.4
1851	51.1	56.8	60.9	66.0	73.4	78.9	82.8	82.2	74.3	67.6	56.7	48.5	66.6
1852	43.2	53.0	60.2	62.9	73.8	76.6	81.4	79.8	75.8	70.5	58.5	56.3	66.0
1853	45.2	53.2	58.2	66.6	76.4	79.4	82.8	80.8	77.1	65.7	60.5	54.2	66.5
1854	40.8	53.1	62.7	62.8	73.4	78.6	82.1	82.4	78.9	67.9	56.3	47.8	65.6

KEY WEST, FLORIDA.

DATE.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1830	71.1	73.0	74.5	75.5	80.0	82.0	82.7	83.2	81.3	79.3	75.5	72.5	77.9
1831	67.1	68.5	74.7	76.2	78.1	80.4	81.7	81.7	81.0	78.4	76.0	70.0	76.1
1832	68.4	74.3	72.3	75.4	80.2	80.6	83.3	80.5	80.4	75.6	71.1	70.6	76.1
1833	68.3	71.7	72.0	..	..	..	..	..	..	..	..	68.5	..
1834	71.9	72.2	74.3	74.0	78.1	83.0	82.5	83.0	80.9	76.7	70.8	70.5	76.5
1835	67.6	64.4	71.2	74.9	78.6	80.8	82.0	81.3	79.6	73.9	75.7	68.4	74.9
1836	69.0	67.4	71.0	76.8	..	..	..	..	..	..	71.4	..	..
1837	66.2	68.8	70.8	73.1	77.9	81.3	82.3	82.0	81.0	77.8	76.1	70.3	75.6
1838	71.1	62.2	70.6	73.4	77.0	79.5	82.1	82.8	81.7	78.5	73.4	70.2	75.2
1843	..	..	..	78.1	81.2	84.0	85.2	84.2	82.1	79.9	77.1	72.9	..
1844	..	68.7	71.0	75.0	78.9	81.3	83.6	83.9	83.5	78.8	77.3	79.2	..
1845	70.0	68.9	74.1	77.0	78.6	80.7	83.5	..	..	..	..	..	..
1850	..	..	..	..	..	..	85.3	84.8	83.1	77.4	73.5	74.2	..
1851	73.8	74.5	74.0	77.2	79.6	81.8	83.5	83.6	81.3	79.8	75.4	70.0	77.9
1852	61.2	70.0	74.4	76.1	80.3	82.8	83.4	82.9	82.1	79.4	76.2	74.6	77.1
1853	68.0	71.3	74.1	76.1	79.6	80.5	83.5	82.9	82.5	80.4	75.7	68.4	77.0
1854	71.7	71.9	76.6	73.9	80.8	83.3	83.3	82.6	82.5	78.2	72.6	66.4	77.0
1855	67.2	65.9	70.3	75.1	79.1	82.7	..	..	..	..	..	..	..

NEW ORLEANS, &c.; BATON ROUGE, (*a*); FORT PIKE, (*b*); FORT JESUP, (*c*).[1]

DATE.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1820	..	..	..	73.0°	79.0°	86.0°	82.0°	85.0°	81.0°	65.0°?	57.0°	60.0°	..
1822	52 9°	51.6°	64.1°	70.3	77.2	84.3	81.5	82.8	79.5	71.4	67.3	57.7	70.1°
1822 *a*	52.4	49.7	62 0	68.0	78.2	84.8	81.2	81.1	76.1	66.7	63.9	51.8	68.0
1823 *c*	51.0	43.3	60.7	71.6	77.1	77.9	83 1	83.2	75.9	69.8	58.5	57.4	67.5
1824 *c*	59.0	54 2	63.9	64.4	76.6	84 8	85.9	83.9	78.0	66.0	57.9	56.6	69.3
1825	53 3	53 3	67.8	66.9	81 8	83.5	82.9	84.3	80.2	65.7	62.6	44.0	68.9
1826	53.2	63 3	70.7	72.5	77.6	83.2	84.1	85.1	80.6	73.0	65.5	58.2	72.3
1827	50.8	65 1	62.7	72.1	73.2	83.6	84.5	82.4	80.6	69.2	62.5	62.7	70.8
1828 *b*	60.0	64.7	64.3	70.5	79.1	83 4	83 2	83.3	78.6	74.0	67.0	64.3	72.7
1829 *b*	55.6	51 2	58.5	65.8	75.5	82.7	83.0	83.3	81.5	72.3	60.8	61.1	69.3
1830 *b*	57.5	59.5	68.2	71.6	77.6	82.0	85.1	84.8	81.6	73.0	68.0	59.5	72.2
1831 *b*	49 3	51.5	65 8	69.4	74.5	80.9	83.2	80.5	78.2	70.9	63.5	47.3	67.9
1832 *b*	54.6	65 3	63.5	71.2	77.9	80.6	82 2	83.8	78.2	72.1	60.1	59.4	70.7
1833 *b*	58.7	60.2	62.1	73.0	78.8	82.7	82.6	81.1	81.3	67.9	61.0	56.4	70.5
1834 *b*	51.4	58.9	64.6	71.2	76.4	82.9	83.1	84.2	78.2	72.1	62.7	56.7	70.2
1835	51 6	49.6	60.4	68.0	79.5	81.8	81.1	83.0	76.6	69.9	63.7	53.9	68.3
1836 *c*	50.7	54 1	55.1	67.8	70.6	76.7	80.3	78.6	75.7	59.8	49.6	46.6	63.9
1837 *c*	45.2	50.4	55.7	62.6	71.5	79.7	80.4	80.4	74.3	67.5	63 6	51.5	65.2
1838	56.6	52.4	64 1	67.2	68.6	82.1	82.5	82.1	77.3	68.4	57.1	52.8	67.6
1839	56.2	54.5	60.9	71.0	77.3	83.0	82.5	82 2	79.2	75.4	57.4	48.1	69.0
1840	55.1	61.8	69.1	74.4	77.3	80.0	85.5	85.0	78.9	74.3	65.7	56.1	71.9
1841	55.4	55.6	64.8	71.6	76.2	84.3	87.0	83.8	79.5	69.2	61.8	55.4	70.4
1842	57.0	58.5	71.3	69.8	75.0	80.5	80.2	79.6	78.6	69.0	59.1	53.3	69.3
1843	54.6	52 4	51.4	71.1	78.3	78.2	81.4	80.2	80.6	68.2	65.1	55.9	68.1
1844	57.6	58.4	61.6	72.1	79.9	81.6	84.3	82.0	79.1	68.2	61.8	53.4	70.0
1845 *a*	54.8	56.8	59.8	71.0	73.9	79.8	80.9	86.0	76.6	66.2	57.7	47.2	67.1
1846 *a*	52.0	54.1	62.3	68.1	75.6	78.8	81.4	80.2	80.0	67.1	62.6	59.6	68.5
1847	54.8	57.3	61.9	71.5	76.5	78.7	81.8	82.7	77.8	71.1	64.4	53.2	69.3
1848	58.2	61.7	64.3	68.4	76.5	82.8	80.4	81.2	79.5	73.7	59.6	59.4	70.5
1849	60.9	56.1	70.3	71.0	76.8	81.1	81.1	85.1	81.0	69.8	66.0	61.9	71.7
1850	59.3	55.3	63.9	68.1	72.3	76.1	82.5	86.1	83.4	66.4	60.6	55.5	69.1
1851	54 4	59.8	61.6	68.2	75.8	83.1	85.2	84.0	80.5	69.7	60.9	55.2	71.5
1852	46.6	62 1	67.0	67.3	78.1	80.8	84.0	83.2	80.9	74.2	61.4	62.0	70.4
1853	50.6	56.5	62.7	70.4	74.3	80.2	82.6	84.3	80.1	65.8	..	51.1	..
1854	53.4	56.5	66.2	64.6	75.1	80.6	80.1	81.5	78.1	69.9	57.1	52.2	68.0

NATCHEZ; DUNBAR, *Phil. Trans.*

1799	..	47.7	51.8	67.0	73.0	79.0	79.8	78.5 ?	75.5	65.5	54.5	46.5	..
1800	43.5	42.5	58.5	66.2	72.0	79.5	81.5	82.0	76.5	66.0	56.0	47.3	64.3
1801	51.0	57.5	61.0	62.0	72.0	82.0	80.0	79.0	77.0	76.0	55.0	49.0	66.7
1802	55.0	59.0	62.0	71.0	..	..	78.5	78.0	76.0	65.0	53.0	47.0	..
1803	47.0	52.0	62.0	69.0	71.0	79.0	81.0	80.0	76.0	73.0	57.0	53.0	66.7

CINCINNATI, DR. DRAKE; DR. RAY.

1806	..	..	..	..	..	..	..	..	..	..	..	..	54.1
1807	..	..	..	..	..	..	..	..	..	..	..	..	54.4
1808	..	..	..	..	..	..	..	..	..	..	..	..	56.4
1809	..	..	..	..	..	..	..	..	..	..	..	..	54.4
1810	..	..	..	..	..	..	..	..	..	..	..	..	52.8
1811	..	..	..	..	..	..	..	..	..	..	..	..	56.6
1812	..	..	..	..	..	..	..	..	..	..	..	..	52.6
1813	..	..	..	..	..	..	..	..	..	..	..	..	52.7
§1819	37.0	42.0	40.0	57.0	66.0	74.0	74.0	77.0	69.0	55.0	51.0	38.0	56.8
1835	34.6	24.5	40.1	50.5	65.3	71.2	71.7	69.1	59.1	55.8	43.3	31.4	51.3
1836	30.6	28.8	36.1	55.6	65.8	70.4	75.8	71.6	69.3	46.2	38.7	30.6	51.6
1837	30.1	36.6	41.8	48.3	62 4	70.1	75.3	72.4	64.9	55.8	48.1	35.5	53.4
1838	36.4	20.9	48.4	50.5	56.7	73.0	79.2	77.6	66.3	50.6	39.0	28.2	52.2
1839	38.4	37.0	44.9	60.2	66.0	69.5	76.1	73.5	61.1	60.3	37.2	30.6	54.5
1840	25.6	42.0	47.7	57.4	63.2	70.8	75.4	74.7	61.8	54.3	40.9	32.4	53.8
1841	32.0	32.5	44.7	51.2	62.1	75.1	79.1	76.4	67.8	51.2	44.2	36.3	54.4
1842	36.7	36.4	52.4	57.6	60.8	69.0	75.6	71.4	66.6	52.2	35.1	33.8	54.1
1843	35.7	26.6	28.8	51.3	62.8	70.4	73.8	70.3	69.3	47.6	40.6	36.2	51.1
1844	31.7	37.4	44.4	64.1	66.8	71.6	78.5	72.6	65.6	49.5	44.2	36.3	55.0
1845	37.9	40.1	44.5	59.9	61.6	72.6	73.4	73.0	64.1	50.2	40.3	24.8	53.5
1846	35.2	31.5	44.1	57.1	67.0	68.1	75.9	76.4	70.7	52 8	45.7	39.8	55.4
1847	30.8	36.7	40.2	55.7	62.7	69.2	74.4	70.5	64.1	53.2	44.9	34.3	53.0
1848	36.7	36.9	42 3	53.7	66.5	71.8	73.8	74.6	62.2	54.0	39.8	41.1	54.4
1849	32.3	32.1	46.5	52.6	63.9	73.9	73.6	73.5	65.3	53.3	49.9	31.6	54.1
1850	36.6	35.6	41.2	49.0	58.9	73.2	81.6	78.2	65.9	53.4	46.4	34.6	54.5
1851	36.1	42.4	46.4	52.0	65.8	71.3	79.1	76.4	69.4	53.7	40.9	30.3	55.3
1852	27.3	36.8	46.2	50.7	64.7	68.8	80.1	75.1	65.1	50.2	41.4	39.9	53.9
1853	34.5	35.6	42 2	54.4	63.4	75.6	75.6	76.2	66.9	50.1	47.6	32.7	54.6
1854	32.5	39.2	46.8	53.9	64.7	72.2	81.5	79.8	73.2	58.9	41.3	35.2	56.6

[1] The first record for 1822 was at Fort St. Philip, sixty miles south of New Orleans. At Fort Jesup the summer is as warm as at New Orleans, but the winter months are 5° colder; a series representing the general district of the lower Mississippi could only be completed by supplying omissions from several posts.

ST. LOUIS—Dr. Engelmann; JEFFERSON BARRACKS. (*a*).

DATE.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1827 *a*	32.1°	44.5°	51.0°	61.2°	65.5°	73.6°	80.1°	81.7°	72.9°	59.0°	50.4°	39.1°	59 3°
1828 *a*	37.1	42.8	49.4	55.8	70.0	80.7	79.4	81.5	67.9	50.7	50.5	44 8	59 2
1829 *a*	36.3	20.5	42.6	60.2	73.7	77.2	76.8	77.0	65.8	56.9	37.1	42.3	55.5
1830 *a*	32.8	37.5	48.0	61.5	66.4	75.7	79.8	78.7	67.6	60.7	51.4	42.1	58.6
1831 *a*	21.5	27.2	43.9	..	..	..	75.4	71.9	63.0	53.7	40.3	18 5	..
1832 *a*	31.1	31.2	50.3	58.9	63.8	80 5	76.5	73.9	66.0	58.6	45.0	36.9	56.1
1833	34.0	38.0	44.6	58.5	69.3	72.9	78.5	79.4	68 0	58.0	44.0	36.3	56.8
1834	20.5	40.5	44.8	58.8	65.3	75.4	81.3	80.6	64 4	53.6	45.9	33.3	55.4
1835	34.4	21.4	42.1	58.0	65.0	72.5	72.5	71.0	65.0	51.0	40.0	30.0	51.9
1836	30.9	32.4	38.3	58.5	68.9	74.7	78.5	73.6	67.8	48.4	40.8	30 0	54.6
1837	29.3	38.5	41.6	49.6	63.5	72.0	78.1	75.4	66 8	58.5	50.0	36.0	54.9
1838	34.7	20.8	50.5	58.4	60.5	75.7	81.6	80.4	68.6	50.6	34.7	27.4	53.7
1839	37.2	38.5	45.0	63.1	66.8	70.3	76.4	74.3	64.4	62.8	38.5	30.4	55.6
1840	26.3	39.7	47.2	61.1	67.3	77.3	76.9	76.0	65.7	55.0	42.7	35.9	55.9
1841	28.6	32.9	46.1	54.9	66.7	77.4	80.9	77.1	68 1	54.3	46.1	37.1	55.9
1842	39.7	37.4	56 7	63.1	66.8	72.7	75.8	73.3	71.8	59.0	37.7	35 1	57.4
1843	36.7	25.3	27.5	55.3	66.8	73.8	79.1	76.8	73.2	51.5	43.2	38.0	53.9
1844	32.9	41.2	46.5	66.7	67.7	75.5	81.6	77.4	67.9	51.4	44.6	36.6	57.5
1845	40.5	44.1	45.3	64.3	64.7	74.7	79.7	77.5	70.8	55.3	42.7	27.4	57.3
1846	38.7	31.4	47.2	58.9	69.3	70.8	81.4	78.6	74 0	56.3	46.3	39.7	57.7
1847	27.1	36.1	41.4	59.3	63.5	72.0	78.6	74.7	69.1	57.1	45.1	34.7	54.9
1848	39.4	40.4	44.5	55.2	69.0	72.5	73.7	74.9	64.4	55.8	38.7	32.9	55.1
1849	25.1	28.4	46.4	53.3	63.9	75.3	75.1	73.8	68.5	50.3	49.0	29 0	53.1
1850	34.0	33.7	41.3	48.5	61.5	76.8	80 8	81.5	69.3	51.1	44.7	29.8	53.7
1851	36.2	38.8	48.3	52.8	69.0	72.9	78.0	75.6	72.5	56.1	41.1	30 5	56.0
1852	26 9	37.6	46.9	52.1	66.9	71.2	78.0	73.5	67.2	60.8	38.5	31.5	54.5
1853	34.1	32.7	42.0	56.0	63.6	78.0	75.2	76.9	69 5	52.7	48.1	33.5	55.1
1854	28.4	39.4	47.4	56.8	67.9	76.5	84.0	82.3	76.0	60.9	43.3	37.1	58.3
1855	32.9	29.0	38.3	61.2	65.6	70.2	78.4	73 7	72.4	53.1	45.9	31.6	54.3
FORT SNELLING, (NEAR ST. PAUL'S) MINNESOTA.													
1819	..	..	..	..	..	..	..	..	..	44.1	33.0	20.0	..
1820	0.9	21.3	26.4	52.7	60.6	70 9	68.9	68 3	62.0	..	30.7	10.8	..
1821	7.4	14.5	29.0	40.6	57.1	74 3	72.3	75.1	59.0	48.7	30.7	10.6	43.3
1822	11.7	19.9	37.4	43.7	61.3	70.2	75.5	72.8	60.6	42.5	30.6	3.3	44.1
1823	13.2	5.9	29.9	49.3	56.9	74.0	75.8	72.0	56.0	47.1	31.7	13.6	43.8
1824	17.2	14 2	23.8	41.8	56.3	66.0	73.0	70.5	61.0	41.9	30.0	22.2	43.1
1825	14.8	26.2	36 3	55.2	60 9	70.7	75.5	73.0	62.9	46.0	33.9	14.4	47.5
1826	13 6	16.2	29.6	37.7	66 7	72.0	73.8	70.2	55 3	49.1	35.3	19.2	44.9
1827	17.3	24.9	31.7	44.7	62.9	71.9	74.1	70.3	61.0	49.3	32.0	13.0	46.1
1828	10.4	16.8	32.2	45.0	60.3	71.8	76.4	74.5	58 8	50.1	35.2	24.9	46.4
1829	16.0	7.5	29.9	48.0	68.2	73.6	73.6	71.3	57.8	50 5	27.1	25.1	45.7
1830	14.2	23 6	34.0	51.8	59.7	70.3	81.7	73.2	58.7	54.7	42.8	15.6	48.4
1831	8.8	14.0	32.3	45.1	61.1	70.1	73.8	71.5	54.8	48.3	31.2	3.3	42.9
1832	17.2	6.5	38.0	54.0	55.9	65.9	73.7	67.6	60.5	50.7	33.5	25.8	45.8
1833	21.2	20.9	34.1	51.7	61.1	68.0	75.2	70.7	62.6	41.4	37.1	31.4	48.0
1834	5.6	31.2	32.3	51.7	61.8	67.2	77.7	73.3	56.7	45.8	40.0	21.8	47.1
1835	23.5	9 3	32.7	44.0	62.5	68.3	70.6	68.0	54.6	45.7	24.4	17.3	43.4
1836	12.4	17.0	20.3	43.7	64 3	67.4	72.1	66.1	56.8	41.9	34.4	19.0	43.0
1837	19.5	25.1	24.5	41.3	54.1	64 5	71.3	67.9	58.4	46 5	37.8	17.8	44.0
1838	9.7	4.5	37.4	41.8	53.1	70.4	75.6	72.7	61.1	42.7	20.5	11.4	41.8
1839	22.5	24.8	29.6	57.3	57.2	67.1	73.9	71.1	56.3	54.4	30.1	22.1	47.2
1840	12.4	21.9	34.8	47.5	63.8	69.6	70.5	65.9	56.9	40.9	29.5	24.1	44.8
1841	13.8	20.5	33.2	38.2	59.7	69.8	72.3	68.3	54.4	44.8	30.4	19.8	42.9
1842	17.8	19 5	39 2	49.8	51.9	56.0	68.4	67.7	58.2	49.3	24.6	18.0	43.4
1843	20.7	2.0	4.7	43.6	52 2	63.0	69.9	66.6	57.9	47.7	26.6	23.1	39.8
1844	9.4	22.3	32.9	51.4	55.1	62.6	69.8	65.6	55.6	41 5	28.1	17.1	42.6
1845	19.5	25.6	31.6	47.6	60.8	67.6	74.2	69.5	59.8	45.6	29.5	14.1	45.7
1846	28.8	19.5	38.4	46.4	63.6	66.8	74.2	73.9	62.8	42 9	39.8	21.6	48.2
1847	4.2	19.7	23.9	46.2	52.6	65.2	71.9	66.7	58.0	46.7	30.4	16.4	41.8
1848	16.9	19.5	28.2	44.8	60.1	67.4	67.0	67.2	54.0	50.2	25.7	8.6	42.5
1849	5.4	12.9	30.3	39.7	54.8	68.2	71.6	63.8	61.5	47.2	41.6	8.8	42.3
1850	13.8	17.8	24.1	35.4	55.8	70.5	75.8	73 9	61.1	49.2	33.7	12.4	43.5
1851	14.9	22.1	39.4	50.1	58.0	67.8	76.3	68.4	69.1	52.1	30.3	11.2	46.5
1852	12.8	23.1	26.8	43.1	58.5	70.1	73.7	71.6	54.2	53.1	25.7	11.7	43.7
1853	14.0	6.7	23.0	45.0	55.0	67.8	70.6	71.3	60.0	45.6	29.6	18 2	46.7
1854	1 3	15.4	30.7	48.5	57.8	70.0	75.0	71.1	61.7	52.1	32.3	20.7	44.7
1855	17.1	12 6	25.3	49.9	61.3	66 1	..	..	..	..	..	..	..
FORT LARAMIE: MATAMORAS; AND FORT BROWN, TEXAS.													
1849	..	..	..	..	..	..	..	..	62.0	43.5	37.3	23.9	..
1850	27.3	36.3	35.5	43.2	56.1	66.9	72.9	73.5	67.1	54.6	35.1	26.6	49.6
1851	35.6	31.2	41.0	47.4	55.2	67.2	77.4	72.7	69.3	51.5	33.2	21.7	50.5
1852	30.7	33.0	30.0	42.8	57.1	67.2	75.1	73.1	58.8	49.6	25.2	19.9	46.9
1853	34.1	29.7	36.9	48.6	51.6	65.6	73.0	73.2	61.1	49.7	41.7	33.7	49.9
1854	22.6	36.4	41.1	50.6	56.9	67.7	75.2	76.5	66.9	56.6	42.4	38.9	52.7
1855	35.8	29.0	36.4	52.9	59.8	69.4	..	..	..	..	..	..	..
1847	58.5	64.1	67.7	77.3	82.4	84.8	85.4	84.5	80.9	76.3	70.2	61.4	74.5
1848	65.4	66.2	69.6	72.0	81.2	..	..	..	..	..	..	..	..
1849	..	..	..	..	..	..	..	..	79.0	71.0	69.0	62.2	..
1850	62.5	66.0	70.6	73.2	74.3	80.4	84.9	84.8	84.7	76.2	67.3	58.2	73.5
1851	60.5	65.8	66.7	75.2	81.6	83 1	82.4	85.8	79.8	73.2	61.9	57.9	72.9
1853	56 3	59.8	69.9	78.7	79.0	82.1	84.4	82.8	78.9	71.1	69.4	62.3	72.9
1854	59.3	62.5	71 9	73.9	81.0	83.7	84.1	82.0	81.1	.76.4	70 3	60.7	73.9
1855	60.2	61.6	66.2	75.0	81.8	81.1	..	..	..	..	..	..	..

LAREDO, TEXAS: FORT FILLMORE; SANTA FE, NEW MEXICO.

DATE.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1849	..	..	..	..	..	..	86.4°	84.6°	80.7°	71.2°	66.1°	56.7°	..
1850	60.8°	61.8°	68.6°	74.0°	76.4°	82.0°	86.1	90.1	86.6	75.7	62.8	50.8	73.1°
1851	57.7	61.2	67.9	74.8	82.9	86.0	86.4	90.3	82.5	73.2	60.2	55.1	73.2
1852	50.6	67.7	71.5	77.6	84.5	84.7	87.3	89.6	82.2	75.1	66.6	59.6	74.7
1853	55.2	57.0	66.4	78.2	81.7	84.3	87.7	85.7	82.4	72.9	68.0	57.7	73.1
1854	53.0	60.0	74.2	77.2	81.4	83.7	84.1	84.5	81.1	77.2	64.3	53.8	72.9
1855	56.6	57.3	65.3	78.1	84.2	82.7	..	..	..	..	..	..	..
1851	..	..	..	..	..	..	..	..	79.6	63.2	48.2	44.1	..
1852	39.7	49.7	48.4	56.5	68.7	78.1	79.6	76.4	74.3	59.0	46.0	44.1	60.0
1853	41.7	45.0	52.7	65.5	72.5	81.8	85.3	81.4	77.5	65.0	57.5	50.8	64.7
1854	48.6	50.4	59.7	66.1	68.6	80.6	85.1	81.2	77.4	70.4	53.2	46.7	65.7
1855	47.9	50.6	61.0	69.4	75.5	83.2	..	..	..	..	..	..	..
1849	32.9	35.1	43.2	53.0	54.7	71.3	..	70.2	64.4	48.9	39.6	33.5	..
1850	30.2	31.9	40.9	50.7	..	..	76.2	75.3	..	55.7	..	23.3	..
1851	34.0	34.2	..	49.4	59.0	69.4	72.9	..	..	..	..	..	..
1852	..	..	..	..	..	..	..	..	59.6	47.9	34.4	29.6	..
1853	31.1	28.0	37.8	53.9	60.3	66.4	69.4	66.7	62.7	48.3	40.3	31.4	49.7
1854	28.5	34.1	41.5	49.8	54.2	68.2	71.8	67.7	61.1	55.5	40.0	33.3	50.5
1855	31.9	36.2	40.1	50.9	..	..	..	..	..	..	..	..	..

FORT YUMA; SAN DIEGO; SAN FRANCISCO, CALIFORNIA.

DATE.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1851	54.4	53.2	62.6	72.9	..	..	..	..	..	..	..	..	..
1852	..	..	..	..	..	87.0	88.6	88.1	83.6	72.9	61.5	55.5	..
1853	59.3	58.6	67.6	73.2	77.7	89.5	94.1	92.2	89.3	79.4	65.7	57.1	75.3
1854	54.2	59.2	64.5	74.7	74.1	85.4	94.0	90.6	85.5	77.2	66.0	59.5	73.8
1855	57.9	61.2	69.7	73.0	78.4	..	..	..	..	..	..	..	..
1856	..	..	..	..	..	..	95.5	..	..	..	..	..	..
1849	..	..	..	..	..	..	74.3	75.3	69.9	64.1	56.4	51.0	..
1850	51.2	52.4	51.9	59.4	61.9	64.0	67.4	74.5	71.4	66.3	56.5	48.7	60.7
1851	51.3	50.3	55.2	..	..	..	..	..	..	..	56.4	52.7	..
1852	53.1	55.7	55.1	57.7	61.3	67.1	73.2	72.5	73.6	65.1	57.2	51.7	61.9
1853	53.8	52.9	57.8	62.7	63.4	68.4	72.8	72.9	70.7	68.9	58.4	53.5	63.0
1854	51.9	52.5	54.6	62.6	60.7	65.0	73.1	73.2	67.6	63.0	56.6	52.6	61.1
1855	50.1	55.7	58.4	63.7	66.1	72.4	..	..	..	..	..	..	..
1852	..	..	..	..	..	..	59.8	58.1	58.5	55.5	54.6	50.1	..
1853	51.0	49.9	53.1	54.9	56.4	57.6	56.6	56.9	58.9	59.7	55.9	51.3	55.2
1854	47.9	51.7	52.0	56.1	53.6	55.3	57.2	56.7	57.3	59.0	56.4	52.0	54.7
1855	50.1	55.0	56.6	56.0	56.0	57.4	..	..	..	..	..	..	..

PUGET'S SOUND, WASHINGTON TERRITORY.

DATE.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1849	..	..	..	..	..	..	..	..	..	..	46.8	36.3	..
1850	35.9	39.1	40.5	47.3	55.6	61.1	64.2	63.4	56.5	51.9	41.2	37.9	49.5
1851	40.6	40.8	43.2	51.5	54.4	61.2	62.9	66.8	57.0	52.9	46.3	41.1	51.5
1852	43.2	42.6	40.2	46.5	57.1	63.0	63.5	63.9	57.1	51.7	43.7	33.3	50.5
1853	39.7	39.8	41.9	48.7	57.6	60.5	66.7	62.1	58.6	53.6	45.1	44.6	51.6
1854	30.6	39.6	43.9	50.8	55.6	59.0	63.7	62.8	59.6	51.7	46.7	43.1	50.6
1855	41.9	43.2	47.7	48.4	54.8	59.1	..	..	..	..	..	..	..

ST. PETERSBURG, RUSSIA.

DATE.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1822	20.9	31.3	34.5	42.6	48.3	54.6	62.8	60.2	51.7	41.7	32.4	28.2	42.25
1823	9.2	13.4	31.4	33.6	46.2	61.2	62.6	61.9	50.9	44.1	26.0	27.3	39.00
1824	20.8	20.5	27.6	37.5	46.3	53.7	58.8	56.8	55.4	39.2	31.6	26.4	39.55
1825	23.2	20.9	25.3	34.6	43.7	58.4	58.4	59.4	48.8	41.9	35.8	22.1	39.40
1826	11.7	20.0	29.8	38.8	55.1	63.6	69.2	65.3	51.4	48.1	35.5	31.3	43.10
1827	20.2	15.5	28.4	45.2	52.5	61.9	62.1	61.4	52.5	38.8	27.2	24.9	40.90
1828	10.3	9.8	20.5	35.7	50.7	61.1	67.2	62.4	49.6	40.7	27.9	14.0	37.50
1829	9.8	7.9	15.9	31.1	47.7	58.5	68.2	59.2	53.6	37.6	26.1	16.9	36.05
1830	12.4	15.1	25.0	36.3	43.4	59.1	62.6	63.3	49.6	41.2	32.3	22.3	38.56
1831	9.4	22.7	18.0	37.0	46.6	61.5	66.2	59.6	47.5	39.7	30.8	19.9	38.30
1832	18.5	25.3	25.4	34.7	46.0	56.6	57.5	57.9	45.2	41.2	24.3	18.7	37.90
1833	16.8	21.5	19.8	35.4	46.6	61.5	63.0	55.4	52.5	42.1	35.1	18.0	38.98
1834	6.6	17.7	25.7	34.7	47.6	55.6	63.2	64.7	49.9	40.2	28.6	21.7	38.00
1835	21.2	25.4	28.8	34.5	45.6	60.0	61.9	55.4	51.9	40.8	23.4	11.0	38.35
1836	14.5	21.3	34.5	42.4	44.6	55.6	58.8	57.2	49.0	44.7	28.9	22.3	39.48
1837	15.1	24.4	25.4	35.4	49.1	56.3	57.9	61.7	50.0	36.8	34.2	18.4	38.50
1838	3.9	5.2	18.5	35.2	46.1	54.4	62.1	59.0	56.0	37.9	29.1	25.4	36.08
1839	18.7	15.3	14.2	28.3	56.4	57.6	66.3	62.6	52.7	40.0	26.1	6.6	37.10
1840	18.2	14.7	19.8	33.5	45.1	57.8	61.7	59.1	51.9	37.2	24.3	9.0	36.00
1841	14.2	14.0	25.9	39.8	52.2	63.3	61.9	62.1	50.3	42.3	30.8	30.0	40.60
1842	13.0	27.3	26.0	31.1	51.6	57.0	62.2	62.8	48.7	37.2	28.2	29.0	39.48
1843	28.6	28.1	24.4	31.7	41.9	59.7	62.3	64.0	50.1	40.4	27.7	27.3	40.54
1844	16.2	5.0	22.7	35.3	52.4	55.8	60.9	61.9	52.1	40.5	22.8	16.8	36.90
1845	25.9	7.7	13.4	29.3	42.6	55.2	63.4	61.1	51.1	38.1	34.3	24.3	37.22
1846	13.7	9.7	31.3	36.3	44.6	54.0	65.5	66.6	50.6	45.5	29.5	17.1	38.72
1847	20.2	11.9	22.0	29.2	44.6	60.2	59.7	64.8	56.1	39.9	35.6	25.2	39.20
1848	8.6	25.4	32.6	42.5	48.6	57.5	59.9	57.9	50.9	39.4	30.9	17.7	39.53
1849	8.9	19.8	22.5	33.5	46.7	53.1	61.5	60.6	50.4	39.4	33.1	17.8	37.20
Mean[1]	15.7	17.6	24.3	35.6	47.7	58.2	62.7	60.9	51.0	40.6	29.3	21.2	38.73

[1] 25 years, 1822–1846; the series corrected to absolute means.

MONTHLY EXTREMES OF TEMPERATURE.

ST. JOHNS, NEWFOUNDLAND, TEMPLEMAN.

DATE.	Jan.		Feb.		March.		April.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.	
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1834	36	—7	40	—14	46	—6	46	13	57	24	76	30	86	37	78	36	74	36	70	28	52	15	45	4
1835	44	—5	47	0	47	—2	51	19	60	25	73	29	80	37	81	43	77	35	70	25	54	14	46	8
1836	48	4	48	1	55	2	60	14	66	18	80	27	81	30	78	40	74	30	71	22	61	20	47	2
1837	46	0	40	—6	45	2	60	25	60	25	73	29	72	33	78	41	75	33	63	21	60	18	37	6
1838	49	—6	40	0	47	3	61	12	65	28	73	30	79	38	76	33	76	32	66	25	59	12	47	2

HOULTON, (HANCOCK BANKS) MAINE.

DATE.	Jan.		Feb.		March.		April.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.	
1829	47	—24	40	—7	52	—1	67	22	91	33	92	35	84	42	92	48	80	30	68	24	60	—2	50	—2
1830	34	—23	44	—15	56	0	80	25	75	30	88	42	95	47	78	45	75	35	76	25	60	10	55	—6
1831	52	—13	46	—9	54	—1	65	17	84	33	88	47	88	44	86	40	78	35	70	27	56	12	33	-16
1832	57	—19	40	—16	68	—1	59	9	86	26	77	39	83	49	87	44	85	35	68	26	63	6	35	-11
1833	41	—24	48	—14	50	—15	85	14	82	31	82	35	85	49	85	39	74	34	64	26	55	—4	48	3
1834	37	—17	45	—11	55	—4	75	15	74	25	84	40	92	50	89	46	85	32	70	23	50	10	34	-18
1835	45	—21	38	—23	40	—15	55	16	74	29	83	43	80	47	85	42	80	36	69	27	60	—6	40	-18
1836	43	—13	39	—14	60	—10	68	13	85	20	93	38	99	52	90	39	90	35	71	20	68	13	43	-23
1837	36	—13	54	—16	68	—11	75	29	73	16	87	41	85	50	87	50	84	41	75	29	50	12	38	-10
1838	50	—10	30	—4	86	16	71	8	82	31	98	53	95	54	91	39	84	33	81	16	48	1	36	—6
1839	47	—24	58	—12	55	4	78	28	66	28	83	39	91	58	97	47	82	31	67	23	56	14	41	—2
1840	34	—19	46	—13	46	—6	77	12	84	36	88	32	92	53	87	60	75	36	70	21	53	16	41	—7
1841	48	—12	46	—19	58	—6	61	6	80	30	84	42	89	45	95	41	89	33	62	21	73	18	46	—8
1842	52	—18	46	—6	55	3	81	2	76	31	86	36	96	46	93	40	79	27	67	19	47	6	45	-14
1843	49	—16	42	—21	46	2	67	16	82	25	89	35	80	44	82	41	78	31	65	25	43	—6	42	5
1844	48	—22	46	—13	49	—7	79	3	69	32	86	39	79	43	79	41	84	28	62	24	62	0	40	-11
1845	43	—10	49	—19	48	—2	71	7	82	26	89	39	89	43	87	34	..	..	..	..	..	..	..	..
Means	45	—17.5	44.5	-13 6	55.6	—3	71.4	14	79	28.3	87	39.7	88.4	48	87.6	43	81.3	33	69	23.5	56.5	6.2	42	—9

NEW BEDFORD, MASS., SAMUEL RODMAN.

DATE.	Jan.		Feb.		March.		April.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.	
1812	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	69	33	60	23	49	11
1813	48	0	46	8	62	6	68	30	72	33	87	44	87	56	88	54	88	50	66	27	65	23	51	11
1814	42	0.5	51	4	64	4.5	74	29	85	41	78	46	83	50	83	50	86	41	75	31	60	22	44	7
1815	49	—9	42	2	59	12	63	30	75	35	83	49	91	45	84	52	79	42	74	26	60	26	49	10
1816	44	4.5	54	—2.5	59	4.5	74	25	78	27	95	38	77	50	89	48	80	37	74	34	68	20	51	5
1817	50	3	47	—15	54	10	78	27	76	39	77	42	85	56	83	52	78	45	72	28	65	18	55	4
1818	48	0	46	0	62	13	61	30	87	40	95	51	96	57	88	52	81	42	70	32	63	25	46	6
1819	50	8	59	15	51	11	62	22	73	38	90	53	90	53	88	50	86	45	83	41	66	24	52	8
1820	38	10	51	1	61	9	72	23	73	35	91	45	90	62	91	60	84	39	70	29	59	16	45	7
1821	45	—10	50	18	54	14	64	25	80	36	86	48	88	52	87	54	81	45	74	32	58	24	50	6
1822	46	—2	50	7	61	19	69	27	81	42	85	50	86	62	83	55	84	42	71	31	64	26	64	10
1823	51	4	44	4	59	5	64	31	77	35	88	43	85	51	82	53	79	34	72	33	56	16	54	15
1824	52	6	52	2	53	16	65	31	71	36	80	46	84	58	81	52	80	42	71	27	61	21	56	19
1825	49	11	47	11.5	57	26	73	27	74	36	88	52	90	60	84	52	77	44	76	28	61	18	56	—2
1826	52	—2	55	—6	57	19	60	19	90	42	84	47	88	58	82	59	77	45	71	30	61	22	57	7
1827	45	—1	48	2	60	17	67	29	79	37	81	48	88	53	91	54	80	48	69	32	60	20	53	10
1828	52	6	54	17	73	16	64	31	76	42	89	49	88	57	90	57	87	49	72	27	60	23	60	11
1829	49	—3	43	7	54	16	67	34	79	42	82	47	83	54	82	51	85	37	66	27	58	23	58	14
1830	51	—4	48	—0.5	65	19	75	33	71	39	86	49	92	55	85	57	78	38	70	33	62	32	58	6
1831	55	—2	48	8	60	23	61	31	86	38	92	54	85	52	90	61	82	43	74	37	60	22	42	—1
1832	57	—1	58	3.5	62	14	71	22	75	36	88	45	85	51	85	52	82	44	68	32	62	21	50	14
1833	64	5	47	7	59	0	79	30	78	39	80	50	89	53	82	47	82	40	72	23	61	18	46	14
1834	51	5	54	6.5	57	20	76	31	72	34	89	47	89	54	89	52	82	35	73	27	54	23	54	—4
1835	51	—3	51	7	54	5	69	23	84	36	81	45	86	49	84	46	76	40	72	36	64	12·	50	-10
1836	46	6	46	—2	50	11	64	21	80	33	85	39	88	52	81	48	85	37	70	24	56	16	52	—1
1837	44	4	44	—1	52	7	67	28	78	26	85	45	85	54	84	50	78	43	73	28	61	14	53	6
1838	48	5	47	3	61	18	61	21	76	34	86	47	93	59	89	53	79	42	72	30	60	6	48	8
1839	55	—7	47	4	62	6	69	28	85	37	80	45	86	58	82	52	77	43	71	31	60	17	48	9
1840	46	—3	55	—3	51	10	72	25	77	39	80	46	82	56	82	55	77	45	70	31	54	19	49	0
1841	46	4	44	2	60	12	61	26	75	32	85	46	82	50	80	53	79	51	61	28	61	18	51	6
1842	52	2	56	10	67	15	56	18	70	35	78	40	80	55	81	51	77	34	69	32	63	18	45	3
1843	49	9	41	3	45	13	65	23	73	40	80	38	82	52	85	54	85	36	70	33	58	22	46	9
1844	45	—2	51	8	56	12	80	26	74	40	84	46	85	48	83	53	78	33	67	34	60	13	53	11
1845	46	7	55	0	65	16	65	31	82	35	85	46	90	54	85	51	81	43	72	26	62	17	53	8
1846	46	7	48	—0.5	60	16	74	29	68	38	74	47	89	54	91	44	86	48	78	29	63	24	55	11
1847	54	7	46	4	54	18	65	23	75	35	86	49	86	51	78	53	79	44	66	23	68	8	60	10
1848	55	—3	47	3	63	9	66	30	77	42	91	45	78	53	83	51	78	35	70	35	57	14	56	10
1849	47	—2	43	0	61	20	65	22	68	39	92	47	95	52	83	56	79	46	64	33	68	28	51	8
1850	49	10	53	0.5	54.5	10	68	26	70	37	84	43	87	53	81	53	77	41	65	28	60	25	49	7
1851	50	1	50	—1	64	18	59	23	78	37	86	43	85	53	80	49	81	35	71	32	60	17	52	1.5
1852	45	0.5	51	2.5	61	11	64	26	77	35	84	47	89	54	80	55	82	42	69	32	57	20	57	10
1853	50	6	50	7.5	62	12	64	31	78	36	89	41	85	58	89	56	80	46	70	32	63	14	47	7
1854	52	—4.5	48	0.5	65	14	66	25	78	31	83	48	92	59	86	57	84	39	72	33	71	18	49	3
1855	54	10	41.5	—14	58	12	76	20	73	37	90	50	87	59	82	49	86	39	70	36	61	21	55	9
1856	39	—5	41.5	—1	46	1	63	24	75	40	93	50	93	56	..	..	..	..	..	..	..	..	..	..
Means	49	1.7	49	3	58.5	12.7	67.4	26.5	77	37	86	46	87	54	84.5	52.6	81	41.6	71	30.6	61	20	51.8	7.1

Previous to July 1839 the extremes were observed by Six's self registering thermometer, and they are therefore *absolute* extremes; subsequently they are the extremes at the hours of observation, which would be nearly the absolute extremes to August 1853. For the remainder of the record the *summer months* will not show sufficient range, the others will be nearly correct.

NEW YORK CITY, (FORT COLUMBUS.)

DATE.	Jan.		Feb.		March.		April.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.	
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1822	60	—1	68	10	76	22	84	24	84	34	98	58	100	62	94	60	89	50	86	37	71	33	63	13
1823	54	12	48	3	63	3	76	30	90	39	90	52	91	60	90	60	90	45	76	34	56	22	48	20
1824	54	9	55	2	59	18	72	32	79	42	90	50	96	62	90	58	86	48	76	34	63	26	59	23
1825	47	15	51	9	69	30	82	29	90	43	97	56	104	67	94	62	83	49	85	35	63	19	50	—3
1826	48	—1	55	1	67	17	63	20	91	44	95	51	97	62	94	66	87	51	77	35	62	26	55	3
1827	43	0	48	7	64	18	76	36	84	41	89	50	96	63	95	62	84	50	71	34	61	21	48	17
1828	54	9	60	17	76	24	69	32	78	44	90	60	99	63	95	63	92	53	71	33	63	27	54	20
1829	44	7	41	11	78	24	82	36	91	40	89	58	95	62	91	61	92	46	78	39	70	26	69	26
1830	49	5	55	8	70	21	81	40	84	47	94	58	98	64	94	65	89	50	76	48	67	38	48	10
1831	54	8	44	10	62	29	72	29	92	40	97	56	92	60	98	56	86	50	78	40	58	26	34	11
1832	50	1	50	11	61	16	78	30	78	41	89	48	93	56	97	52	83	52	74	32	62	28	48	19
1833	59	14	49	14	60	8	79	38	81	49	88	52	94	60	87	54	89	47	73	29	63	27	47	21
1834	53	8	56	16	62	21	80	35	84	35	87	53	94	58	94	70	87	42	75	31	55	24	49	6
1835	49	—1	50	5	58	11	67	31	86	43	86	51	89	54	89	49	81	42	73	42	66	22	42	4
1836	42	9	40	0	47	17	64	26	82	52	86	48	89	61	85	59	89	41	71	29	59	24	49	9
1837	41	10	41	10	52	11	72	32	77	39	80	58	86	60	86	58	78	54	70	35	64	22	54	20
1838	51	15	46	13	54	20	62	32	74	43	84	58	94	62	91	63	83	54	73	32	54	14	44	16
1839	52	6	48	10	58	17	71	32	75	48	79	50	86	61	82	53	82	53	66	41	60	16	59	22
1840	40	2	56	4	63	18	73	34	80	39	91	52	88	61	85	63	80	51	70	31	52	32	48	20
1841	52	9	42	10	62	21	68	30	76	32	92	50	88	60	82	64	82	56	66	34	56	27	50	14
1842	48	16	58	16	62	24	70	32	75	46	79	50	85	64	82	58	85	42	68	36	58	21	44	18
1843	52	12	38	9	46	15	66	29	76	43	93	42	93	57	90	64	92	39	72	38	58	31	46	18
1844	47	3	48	8	54	21	75	27	86	40	92	54	90	59	89	60	84	46	73	36	62	26	48	19
1845	48	14	58	6	70	26	75	30	88	33	94	52	99	54	90	64	86	48	74	30	68	23	42	12
1846	46	9	46	5	62	15	73	34	89	42	86	52	95	57	92	62	88	52	79	32	65	22	50	20
1847	54	16	50	12	56	22	76	26	80	40	94	56	92	58	84	60	84	50	68	32	70	12	56	12
1848	50	3	48	10	60	11	72	32	83	46	91	46	91	57	86	60	82	42	70	40	58	24	58	21
1849	49	0	41	3	66	24	64	25	74	38	90	52	94	57	84	62	80	48	65	40	68	30	39	3
1850	52	16	54	9	62	12	68	28	79	40	88	50	94	62	90	55	82	44	71	34	61	29	50	14
1851	51	8	54	12	68	23	67	34	86	43	90	53	93	62	85	65	88	51	71	38	61	26	46	4
1852	42	—2	49	10	55	24	60	29	72	47	90	56	93	61	87	60	84	45	72	39	60	24	67	18
1853	46	9	52	14	64	15	68	34	86	43	98 ?	51	89	61	94	55	88	41	76	35	65	20	50	18
1854	50	11	46	14	66	19	76	26	80	34	88	51	93	52	90	58	90	47	76	36	66	31	43	5
Means	49.4	7.6	50	9	62.2	18.7	72.2	31	82.1	41.2	89.8	52.9	93	60	89.7	60	85.6	47 8	73.3	35.5	62	24.8	50.2	14.3

ALBANY. (Last five years at Watervliet Arsenal.)

DATE.	Jan.		Feb.		March.		April.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.	
1826	53	—3	53	—12	69	13	83	19	93	43	88	58	91	53	89	55	84	44	74	30	58	24	52	—6
1827	42	—18	48	—8	72	7	77	32	84	37	86	49	88	60	91	52	83	42	68	33	52	21	46	7
1828	46	2	55	18	69	18	65	28	80	43	91	52	93	56	96	53	88	44	73	23	64	15	54	5
1829	48	—10	42	—5	62	13	80	30	92	30	87	54	86	51	89	46	84	36	73	26	66	22	59	13
1830	45	—8	55	—12	70	14	88	31	87	30	85	50	97	56	87	52	84	35	74	33	69	34	49	6
1831	55	—10	44	—2	66	18	80	32	89	36	94	48	90	50	91	50	86	43	76	29	56	21	37	0
1832	50	—8	44	—11	63	8	79	18	86	38	91	49	91	56	90	46	86	42	69	27	59	24	44	6
1833	60	—6	47	—10	66	0	84	25	82	36	86	42	91	54	83	46	78	41	70	22	59	17	42	8
1834	44	—3	56	2	63	14	82	28	88	28	90	48	96	56	94	47	86	30	71	26	58	17	48	—8
1835	49	—23	46	—4	56	5	70	22	86	34	89	50	88	54	87	49	83	32	75	30	63	8	40	-13
1836	39	—12	44	—16	52	1	72	17	86	34	86	45	93	53	84	46	84	39	62	21	62	16	45	—2
1837	39	—10	46	—10	52	—12	72	24	89	28	90	53	88	55	87	51	80	38	72	24	70	3	53	—9
1838	54	—3	39	—6	58	3	68	21	89	33	94	52	96	54	90	50	84	43	75	23	60	1	41	—2
1839	55	—12	50	—5	64	—2	74	30	83	34	86	48	92	55	88	47	86	37	74	21	56	13	50	0
1840	43	—23	60	—6	65	7	85	24	92	39	93	45	96	50	87	55	81	42	74	25	57	23	44	3
1841	49	—12	49	—5	61	1	76	21	87	31	94	56	96	54	91	52	84	42	67	24	70	15	50	—2
1842	50	—4	56	5	70	14	85	15	79	37	86	40	91	54	85	31	85	34	70	32	58	14	43	—5
1843	53	—12	36	—14	47	2	75	15	85	36	88	40	93	56	88	56	86	38	70	30	60	15	43	1
1844	43	—12	48	—5	55	10	84	9	80	36	84	48	86	53	86	52	83	37	69	31	53	10	50	5
1845	45	0	56	—7	73	17	80	25	91	38	92	50	97	54	90	55	79	41	72	25	68	16	39	-11
1846	46	—6	43	—11	59	—6	86	26	87	40	84	49	97	56	94	49	89	48	80	24	64	23	48	4
1847	47	5	49	—6	56	8	80	6	83	40	88	49	90	53	84	55	83	41	68	21	68	6	62	3
1848	57	—15	48	—3	69	—1	75	27	83	39	93	42	88	58	89	55	83	34	68	35	58	19	62	5
1849	46	—10	46	—7	64	15	67	24	79	35	92	49	93	50	82	56	75	42	67	33	62	27	43	5
1850	58	—2	40	—6	58	10	70	22	79	40	84	44	88	58	84	50	80	46	68	26	60	20	46	-18
1851	40	—8	47	—4	60	18	64	28	79	36	88	48	94	59	88	50	91	36	74	31	60	12	50	-16
1852	38	—14	50	3	56	—2	67	22	84	38	99	52	97	60	88	53	89	42	78	27	60	18	64	0
1853	48	2	46	4	54	0	76	30	78	30	88	46	89	50	88	50	79	38	68	30	56	14	40	8
1854	48	—10	38	—4	53	10	66	22	74	30	83	46	96	58	86	54	86	40	66	26	68	18	40	-12
Means	48	—8.5	48	—5	51.5	7	76	23	84.5	36	89	48	92	55	88	50	84	39.5	71	27	61	17	48	—1

CHAMBLY, NEAR MONTREAL: MONTREAL, W. S. KAKEL.

DATE.	Jan.		Feb.		March.		April.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.	
1820	28	—15	48	—29	60	—12	72	13	74	54	89	59	91	70	86	65	90	30	77	25	54	8	40	-22
1821	48	—21	45	7	48	—7	68	21	79	50	87	63	87	62	88	55	80	51	68	24	52	—5	41	-13
1822	42	—36	45	—11	60	—11	74	21	81	49	84	65	89	67	89	66	79	51	68	25	53	16	45	—1
1823	45	—26	45	—21	52	—11	70	23	85	42	86	59	88	69	84	68	81	30	73	26	54	12	45	—6
1824	42	—11	51	—23	55	—3	72	28	82	43	89	61	81	69	79	66	80	55	65	25	44	16	44	—2
1825	42	—18	48	—11	53	9	75	27	83	30	89	68	92	70	85	70	81	53	80	23	63	15	47	-13
1826	49	—23	42	—28	61	11	73	15	91	35	86	58	91	73	90	67	84	49	75	27	59	23	54	-16

	Year.		Year.		Year.		Year.		Year.		Year.
1826	96 —28	1832	89 —17	1838	91 —18	1844	98 —22	1850	93 —19	1855	94 —30
1827	86 —20	1833	90 —25	1839	93 —21	1845	96 —18	1851	92 —21	1856	95 —21
1828	98 —20	1834	96 —16	1840	93 —16	1846	96 —13	1852	99 —20	1857	.. —32
1829	94 —23	1835	98 —25	1841	91 —14	1847	102 —18	1853	101 —18		
1830	93 —20	1836	90 —19	1842	94 —13	1848	94 —24	1854	102 —22	Mean	94 5 19 5
1831	97 —17	1837	87 —20	1843	93 —20	1849	98 —17				

PHILADELPHIA: Dr. Coxe; R. Haines; Maj. Mordecai, FRANKFORD ARS.: Dr. Conrad, PENNA. HOSP.

DATE.	Jan.		Feb.		March.		April.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.	
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1798	53	18	44	12	70	30	76	30	80	52	90	62	96	60	96	65	81	45	70	28	60	25	47	18
1799	57	8	60	8	78	5	83	30	82	42	92	54	86	64	85	63	85	49	69	35	68	27	44	17
1800	49	10	48	18	61	24	77	38	81	48	85	55	90	65	85	64	81	54	70	41	58	25	62	25
1801	48	7	63	12	60	31	70	34	82	55	87	54	90	62	85	59	86	47	75	42	61	27	49	21
1802	57	24	50	10	66	24	70	38	71	47	86	58	88	63	88	60	84	48	76	42	57	32	64	12
1803	53	14	55	18	65	14	69	44	72	37	86	58	90	64	86	63	79	54	70	45	60	30	60	22
1804	45	14	47	15	56	19	70	31	78	50	81	61	89	65	92	69	92	53	71	45	66	33	56	13
§1820	40	5	60	—4	68	16	72	30	74	42	87	50	88	60	85	60	82	46	70	29	55	22	47	16
1821	52	—10	59	19	70	12	72	23	83	42	86	55	87	60	92	61	85	36	70	34	55	28	46	10
1822	48	—1	64	11	68	21	79	30	80	48	80	62	86	62	87	56	89	47	76	35	68	31	55	10
1823	53	9	45	3	59	7	79	32	85	33	91	45	87	57	88	53	84	33	74	32	56	18	50	19
1824	60	12	64	5	58	19	76	31	82	38	90	46	89	59	86	50	82	41	73	30	58	20	64	21
1825	49	14	52	5	69	27	78	27	85	39	92	51	96	65	94	59	78	44	83	31	70	23	57	3
1826	59	4	61	2	78	22	80	21	90	44	92	57	90	55	85	59	86	44	74	32	62	25	61	2
§1836	49	2	48	—7	53	12	77	26	87	39	88	48	89	57	85	49	86	43	73	30	67	24	56	10
1837	48	6	49	10	61	7	79	30	81	32	84	53	86	60	89	56	80	44	78	31	70	23	63	19
1838	61	18	55	10	63	18	73	27	82	40	90	50	96	60	92	55	87	50	75	35	64	18	48	10
1839	56	6	52	13	77	16	81	32	86	40	88	49	92	59	87	55	85	43	75	34	59	18	58	14
1840	50	5	70	3	72	20	84	30	86	40	89	47	90	56	89	56	84	35	78	29	66	27	52	14
1841	61	5	54	4	77	21	73	30	94	32	95	51	98	56	90	58	88	55	65	30	72	20	51	15
1842	56	14	61	15	69	26	77	25	83	43	88	42	93	61	87	55	86	40	86	37	62	18	47	15
1843	66	11	47	7	58	15	77	29	79	45	87	42	94	58	86	61	86	42	73	35	66	23	50	15
§1844	56	5	57	8	67	24	83	25	85	43	90	52	93	60	92	56	86	41	72	35	63	26	62	19
1845	60	15	65	9	76	24	77	27	83	38	95	46	96	55	89	59	84	46	78	29	71	21	46	12
1846	56	12	52	8	70	15	83	32	87	42	86	52	97	56	91	59	91	48	81	33	72	23	57	20
1847	65	9	57	14	62	19	82	26	86	44	93	50	93	57	86	59	87	50	76	30	76	12	72	11
1848	59	6	53	15	72	12	78	30	86	45	96	52	91	59	88	59	88	40	76	39	63	24	70	21
1849	60	3	47	6	71	23	72	26	84	41	97	53	95	59	87	63	86	52	72	37	72	33	54	12
1850	59	15	61	11	71	19	74	29	82	40	90	52	91	61	88	57	84	46	76	38	71	31	56	17
1851	57	9	60	14	74	28	74	35	87	39	92	50	92	60	90	54	93	42	76	35	67	29	49	6
1852	50	—2	58	13	72	21	68	32	83	43	94	52	92	64	86	60	86	46	82	39	63	29	64	22
1853	53	9	60	17	72	18	78	36	87	46	94	52	91	62	93	55	91	41	75	33	68	23	59	15
1854	59	12	64	16	78	21	84	28	83	36	96	51	98	64	96	57	93	47	80	34	70	26	49	6
1855	65	17	49	—2	67	7	86	24	85	40	95	53	95	60	87	56	88	47	75	33	69	27	61	14
1856	40	—5	46	2	48	5	80	24	87	40	98	48	98	64	90	53	90	44	78	35	75	31	61	9
Means[1]	56.5	8.2	55.5	9	68.1	17.7	78.1	28.7	85	40.4	91.7	50	93.3	60.7	89	57	87	45	76.2	34	68	24	56.4	14

WASHINGTON, BALTIMORE, AND ALEXANDRIA.

At Baltimore to 1821; at Washington 1822–1835; 1838–1842, Lt. Gillis, registered extremes; Baltimore 1841–1852; last 3 years at Alexandria.

1817	60	5	56	—4	64	18	84	36	83	43	84	41	92	54	88	48	86	44	70	30	74	20	62	6
1818	52	9	59	—2	68	16	70	25	84	37	90	54	94	60	88	63	85	42	74	30	73	25	56	5
1819	60	17	60	13	71	14	74	26	85	35	94	54	96	55	98	53	95	42	78	25	70	22	54	10
1820	54	—2	73	10	76	13	88	18	84	42	94	47	95	58	98	58	90	40	79	26	64	19	50	14
1821	55	—6	63	18	64	15	68	22	90	42	89	55	92	57	95	59	93	47	79	32	62	28	52	10
§1822	44	8	66	16	74	26	88	32	88	48	90	60	92	72	89	69	86	60	80	44	68	40	60	16
1823	57	28	62	18	67	29	76	43	90	50	93	48	91	65	92	63	87	42	76	34	60	24	59	26
1824	66	20	69	11	62	28	76	34	80	49	88	52	90	67	84	63	80	58	71	31	61	27	62	24
1825	50	19	57	16	66	34	77	35	82	46	93	54	95	64	94	62	85	62	87	35	69	25	54	10
1826	60	0	68	11	78	36	81	31	93	56	95	64	95	58	96	62	92	58	83	31	68	31	66	8
1827	54	9	69	34	73	33	83	38	84	50	92	58	98	70	94	70	89	52	77	36	67	25	65	21
1828	66	16	65	23	76	23	70	32	86	48	93	64	94	66	93	65	94	50	76	27	70	29	62	18
1829	54	12	46	8	68	20	82	36	87	47	92	60	92	58	92	60	86	46	72	31	60	24	64	26
1830	54	10	62	4	72	22	83	38	80	52	90	60	96	64	98	60	91	40	76	38	71	36	60	4
1831	63	1	52	3	75	21	78	31	94	33	98	51	93	50	90	51	85	40	80	30	64	18	44	-10
1832	68	1	72	18	69	11	83	32	80	42	93	53	93	64	89	62	86	59	76	41	71	32	56	31
1833	58	12	58	18	62	9	84	39	84	53	90	57	96	62	88	56	94	46	74	28	68	22	48	30
1834	50	8	70	32	76	26	82	39	87	36	90	57	96	66	97	62	84	39	79	34	60	24	53	22
1835	62	—14	56	—2	68	—5	78	36	87	46	94	58	94	60	88	60	80	44	76	43	74	20	50	16
§1838	..	..	..	..	..	..	..	..	..	..	..	..	103	61	99	62	90	47	82	23	68	13	52	3
1839	66	6	66	12	79	15	91	34	96	37	86	48	88	56	91	52	90	33	80	31	65	12	57	9
1840	53	—4	69	—4.5	73	20	87	29	93	35	90	48	92	56	88	59	80	38	81	22	68	20	59	1
§1841	60	2	59	1.5	80	17	74	32	83	34	95	54	95	58	92	54	88	47	67	27	74	19	58	14
1842	63	12	70	14	82	27	85	30	86	43	97	45	..	..	..	..	..	..	..	..	..	..	..	..
1841	50	0	64	5	70	19	66	30	82	34	94	59	95	62	84	65	88	55	67	25	67	22	55	15
1842	57	16	66	13	76	24	80	32	78	42	85	47	92	62	86	53	90	35	76	34	58	15	49	10
1843	60	10	51	10	53	3	72	26	78	45	85	52	92	65	88	68	88	43	73	32	64	25	50	17
1844	48	5	55	6	63	25	78	26	83	52	87	50	94	55	89	55	85	42	69	38	64	24	49	19
1845	56	20	61	13	75	24	80	27	84	39	94	45	97	55	91	57	85	43	79	27	63	19	42	9
1846	63	14	57	8	73	16	82	33	88	40	89	52	95	55	93	58	91	45	85	30	69	20	56	20
1847	54	10	52	18	64	20	84	26	89	46	97	52	98	58	94	57	94	51	81	32	78	16	66	13
1848	59	12	52	24	74	15	82	35	93	45	99	50	97	60	95	60	92	42	81	40	67	26	71	26
1849	56	6	46	11	72	26	78	27	87	44	100	55	93	59	89	60	89	51	74	42	76	34	55	16
1850	65	12	64	13	70	27	72	32	81	48	92	52	89	68	89	62	82	52	70	46	61	36	56	26
1851	50	15	52	17	73	33	69	40	85	43	90	52	92	63	90	53	93	54	80	34	65	30	56	7
1852	50	—5	58	15	70	22	69	32	83	42	94	50	96	63	91	57	95	46	86	36	62	28	60	25
§1853	57	9	60	18	74	20	85	33	88	41	96	56	93	61	91	58	87	43	74	31	69	22	61	16
1854	65	9	67	16	79	20	82	26	84	38	96	41	100	61	100	54	96	44	80	29	71	22	51	12
1855	58	17	43	3	65	16	92	23	86	35	95	48	95	52	90	47	90	42	72	25	72	24	63	13
Means	56	9.5	59	12	69.3	20	79	32	85	43.5	91.7	53.5	94	61	91	59	88.5	46.5	77	33	66.8	24.7	56	16

[1] For the last 21 years.

CHARLESTON, S. C.

1750–1759 by Dr. Chalmers; 1791–1798 Dr. Holmes; 1847–1855 H. W. Ravenel, Esq., St. John's Berkely; 1845–1854 by Dr. Dawson, city registry; 1823–1854 at Fort Moultrie, Sullivan's Island.

DATE.	Jan.		Feb.		March.		April.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.	
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1750	67	25	70	27	78	38	85	41	87	52	96	71	89	67	91	72	88	56	83	44	73	36	73	30
1751	64	23	74	30	76	40	84	56	86	67	94	72	90	72	91	63	85	52	82	40	74	44	76	24
1752	56	18	79	32	81	41	87	49	93	60	92	67	101	74	96	68	84	64	83	55	81	45	74	32
1753	68	35	72	40	79	34	81	42	90	59	91	68	91	75	90	70	88	63	82	44	74	41	76	28
1754	72	32	76	22	81	43	84	44	88	54	90	58	93	70	88	70	87	64	86	48	75	31	70	35
1755	70	41	62	27	79	32	81	46	81	53	88	65	90	65	87	64	85	49	80	33	67	35	70	32
1756	70	26	72	45	75	45	79	46	88	49	94	56	96	73	90	68	87	64	84	41	71	40	72	32
1757	67	27	70	25	75	39	78	45	85	50	89	66	88	70	90	64	86	54	79	49	75	39	75	33
1758	74	31	75	29	71	34	85	35	87	46	91	61	94	68	92	69	86	57	84	43	77	39	61	25
1759	68	27	73	31	74	40	79	55	85	51	92	63	93	65	90	61	85	59	81	45	74	31	71	28
	Year.																						Year.	
1791	90	28	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1847		89	15
1792	96	30	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1848		92	24
1793	89	30	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1849		91	17
1794	91	34	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1850		91	24
1795	92	29	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1851		93	19
1796	89	17	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1852		92	16
1797	88	22	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1853		94	25
1798	88	31	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1854		94	18
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1855		92	21
1845	67	36	71	32	76	40	85	41	85	50	96	53	93	69	91	65	90	55	84	43	75	36	62	20
1846	65	30	62	36	73	36	78	46	85	64	88	66	89	62	88	76	88	62	70	42	75	35	70	34
1847	71	25	76	34	74	36	80	50	80	54	92	71	90	69	89	71	84	64	81	49	79	28	71	30
1848	68	33	69	32	74	33	78	51	86	58	87	70	91	71	89	72	91	61	78	50	70	32	73	41
1849	77	24	74	22	81	38	86	32	90	51	94	68	95	62	93	68	92	56	89	45	79	43	78	32
1850	76	36	70	25	80	35	85	44	93	58	93	56	95	71	94	69	92	59	81	41	76	34	76	30
1851	72	26	74	31	79	31	88	45	90	55	93	65	94	69	92	65	90	55	84	38	76	40	70	30
1852	59	16	76	35	82	35	84	46	92	49	94	63	94	71	94	66	88	60	89	48	85	34	72	33
1853	70	20	76	36	78	41	82	48	94	57	95	59	97	71	94	65	90	51	84	41	76	35	72	20
1854	72	32	69	33	83	42	86	38	84	56	94	54	94	72	95	72	90	59	84	49	76	32	70	26
1823	66	22	57	19	65	35	76	57	82	66	84	69	89	75	84	72	86	60	77	52	68	34	69	30
1824	71	24	69	30	81	40	81	41	92	61	91	70	90	80	89	75	87	67	82	47	76	40	65	38
1831	68	24	65	33	78	43	79	48	82	58	85	70	93	70	89	75	86	55	84	52	73	32	62	28
1832	66	22	76	39	74	36	80	48	84	64	85	64	90	70	88	73	88	64	80	44	77	41	72	36
1833	70	21	67	36	72	32	76	51	87	64	88	69	89	73	88	68	88	61	86	41	75	32	70	36
1834	68	29	77	43	72	40	75	42	86	54	90	72	89	72	91	70	87	62	83	42	74	37	72	39
1835	66	26	67	6	69	26	73	48	82	60	88	73	87	68	90	73	81	61	77	53	75	43	65	35
1840	63	24	70	30	70	45	79	51	82	58	88	67	85	68	85	74	83	61	79	43	75	43	65	31
1841	67	26	62	28	67	40	78	50	81	55	84	68	91	75	88	72	88	64	78	46	76	40	71	31
1842	71	31	71	24	88	45	78	50	85	53	96	52	83	71	85	59	84	63	80	45	67	32	64	29
1843	72	34	64	24	67	34	75	52	80	58	84	71	89	74	87	71	88	67	89	52	74	37	66	30
1844	68	24	66	30	70	39	80	40	81	62	87	73	94	74	89	66	84	56	79	45	74	44	62	29
1845	68	38	67	33	73	42	78	44	84	54	92	63	92	76	90	68	91	58	84	46	75	36	62	19
1846	68	31	66	34	76	33	89	46	86	64	91	67	88	65	88	76	89	62	..	..	78	37	71	27
1847	70	21	70	36	74	37	79	52	88	58	89	70	89	69	90	72	89	62	86	48	82	32	79	32
1848	68	30	67	32	71	49	78	54	..	..	89	76	90	78	90	70	87	64	77	54	67	31	71	48
1849	66	26	68	26	74	44	76	38	84	54	92	72	88	68	91	74	86	64	83	50	72	44	69	38
1850	71	32	72	24	78	38	77	40	84	56	59	55	95	74	94	73	91	60	80	43	76	38	77	31
1851	68	20	70	28	75	40	83	46	91	53	91	60	99	70	92	66	91	52	84	41	72	36	67	21
1852	61	14	77	33	81	35	79	46	85	49	93	63	92	71	90	66	86	61	87	49	81	37	72	37
1853	68	27	71	33	75	35	82	47	84	66	91	66	91	73	92	63	92	57	81	38	77	42	66	31
1854	70	31	68	30	85	37	82	36	91	45	93	53	98	72	93	70	89	60	82	50	80	36	67	34
Means	68	26	69.5	29.6	74.3	38.4	79	46.7	85	56.8	89	66.5	90.5	72	89	70.3	87.3	61	82	47	75	37.5	68.4	32

KEY WEST, FLORIDA.

1834, 1835 and 1838 by W. A. Whitehead; 1836 and 1837 by Dr. Perrine at Indian Key; remainder at Military Post.

1831	82	50	82	57	89	66	86	62	88	70	87	72	88	78	87	75	89	77	81	71	82	69	80	60
1832	78	55	80	65	81	64	82	70	87	75	86	74	89	77	90	74	85	76	84	68	78	62	76	64
1833	78	61	80	62	81	62	82	63	85	72	88	79	86	79	88	80	87	78	84	67	80	58	77	61
1834	81	60	83	63	84	62	83	63	88	67	89	72	89	72	89	77	87	70	86	65	82	54	84	61
1835	80	54	79	45	82	53	86	56	87	70	89	73	90	74	89	74	85	73	85	68	84	60	80	58
1836	81	49	85	47	83	56	86	70	88	74	88	71	88	77	89	80	88	77	86	73	84	61	81	55
1837	79	50	80	52	81	59	83	62	84	68	88	75	88	68	87	72	86	73	86	62	81	58	79	54
1838	79	62	80	54	81	62	82	63	85	64	87	73	88	73	88	75	88	75	87	71	83	66	82	54
1843	..	..	..	..	..	..	90	68	92	70	93	76	96	76	95	73	90	74	88	72	85	65	84	58
1844	..	..	81	54	81	55	83	58	84	74	88	75	93	76	94	75	93	76	86	66	83	66	82	51
1845	83	56	81	54	82	64	85	70	86	73	90	74	91	77	..	..	..	..	..	..	..	..	..	..
1850	..	..	..	..	..	..	..	..	..	..	..	..	91	77	90	80	89	77	88	65	81	60	83	59
1851	82	59	81	64	83	59	87	66	86	74	88	76	91	77	90	75	88	76	87	73	84	60	82	53
1852	76	49	83	57	83	61	85	65	91	73	89	76	89	77	91	75	87	76	86	72	83	63	83	61
1853	80	55	79	59	82	63	83	67	86	73	86	74	88	76	89	79	87	77	87	73	83	69	79	55
1854	80	58	81	64	84	68	83	60	90	73	90	78	89	78	89	78	88	77	84	72	83	58	80	54
Means	80	56	81	55.5	83	61	85	64.5	87	71	88.4	74.5	89.7	76	89.7	76	88	75.5	86	69	82	62	81	57

NEW ORLEANS (*a*) AND BATON ROUGE, LA.

DATE.	Jan.		Feb.		March.		April.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.	
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1822	70	30	72	28	83	38	86	48	96	64	97	72	92	74	90	76	91	58	85	46	80	42	74	18
1826*a*	77	25	84	42	82	52	88	52	92	62	93	75	96	78	94	76	90	64	80	61	83	48	72	34
1827	80	23	86	42	87	42	94	54	90	54	93	68	93	77	95	71	91	64	88	46	83	39	82	41
1828	80	36	75	44	78	52	85	49	90	70	93	77	92	74	92	74	88	65	84	56	78	49	80	48
1829	72	23	70	28	78	42	80	50	90	64	93	72	92	71	92	77	94	66	88	54	80	34	79	39
1830	75	38	78	36	85	45	84	50	88	62	92	68	94	77	98	74	94	60	84	51	83	48	78	27
1831	71	28	72	26	80	38	92	46	90	58	92	68	94	73	89	63	89	54	81	43	79	38	63	25
1832	74	13	80	29	81	32	84	53	89	59	89	65	94	76	94	78	92	60	87	48	80	29	78	40
1833	76	32	76	39	78	27	88	54	90	66	94	70	95	73	93	73	91	62	87	37	79	28	72	36
1834	79	17	80	34	81	40	87	51	90	61	94	73	98	74	97	72	92	61	90	42	82	29	76	34
1835	73	32	76	10	83	30	84	49	92	60	94	70	92	68	92	70	88	55	82	44	83	33	74	33
1838*a*	77	29	80	26	90	40	91	50	91	52	98	64	98	72	90	76	91	63	87	45	84	34	80	22
1839*a*	74	28	76	35	79	32	88	50	96	64	96	69	95	73	96	74	94	65	86	60	82	30	67	29
1840*a*	78	28	84	36	88	52	90	54	94	56	94	70	98	80	100	74	93	64	90	42	80	32	78	32
1841*a*	76	29	74	29	80	50	91	53	90	60	94	72	100	80	90	76	90	62	86	40	84	30	80	36
1842*a*	82	35	78	32	86	50	82	55	85	57	87	72	88	73	87	72	89	72	82	47	78	33	79	31
1843*a*	74	29	74	28	76	33	86	49	87	57	87	71	94	72	94	66	95	66	88	38	82	55	76	35
1844	74	34	80	33	80	38	88	40	91	64	91	62	93	70	93	66	92	50	85	40	86	36	78	27
1845	76	32	76	29	84	38	89	48	92	52	96	66	99	66	96	64	96	56	84	42	82	28	68	21
1846	77	26	74	32	81	41	85	47	92	58	94	64	97	69	95	67	97	61	86	42	84	29	82	26
1847*a*	78	27	79	35	80	41	84	52	87	62	94	71	90	71	91	71	91	66	87	51	83	29	76	31
1848*a*	78	31	77	36	79	43	81	52	88	59	94	70	94	74	92	70	94	63	87	52	75	37	76	30
1849*a*	76	37	77	35	88	46	85	42	92	65	92	70	92	73	96	70	96	63	90	48	90	40	80	31
1850*a*	79	34	84	26	85	36	90	38	92	48	93	58	95	70	100	69	97	62	90	42	85	40	80	24
1851	78	27	88	27	90	30	96	44	98	50	98	64	98	63	99	67	93	47	87	37	81	33	79	21
1852	72	8	77	28	85	39	82	47	88	58	92	57	95	65	93	64	89	54	86	45	84	28	80	26
1853	69	27	77	27	77	44	84	38	88	52	91	64	91	65	93	67	..	..	84	40	..	..	74	27
1854	81	20	77	31	83	43	82	43	91	49	95	66	92	72	92	73	93	71	84	55	79	31	75	28
Means	76	28	78	31.5	82	40.5	86.6	48.5	90.6	58.7	93	68	94.6	72	94	71	92	61	86	46	82	35.4	76	30.4

CINCINNATI, PROF. RAY.

DATE.	Jan.		Feb.		March.		April.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.	
1835	66	3	56	—17	70	1	83	21	91	40	95	45	93	48	89	46	86	33	82	29	76	3	63	9
1836	61	0	62	—7	71	—4	91	25	89	38	95	52	99	55	95	48	93	40	80	27	68	15	55	3
1837	53	5	66	8	73	20	89	26	95	39	95	52	96	57	94	52	90	42	80	26	75	22	73	7
1838	69	8	51	—10	85	11	85	28	87	36	93	53	97	59	106	62	91	39	84	30	65	14	54	—4
1839	66	13	70	5	79	2	83	32	94	36	94	46	96	54	95	47	88	31	88	32	61	2	48	8
1840	55	—1	75	0	75	21	91	27	89	42	93	47	96	50	93	57	85	41	82	19	71	18	58	7
1841	54	—7	58	4	83	18	82	30	93	37	99	53	98	59	96	59	93	42	76	25	72	25	64	18
1842	65	9	64	—5	85	25	90	27	88	36	95	45	92	56	93	53	94	40	84	27	77	8	69	0
1843	67	2	58	—2	59	1	88	26	93	41	97	38	98	50	92	53	92	48	77	19	68	22	60	15
1844	56	—1	70	15	72	20	89	28	89	45	90	54	94	65	93	56	89	38	76	26	75	15	64	8
1845	62	19	70	8	77	18	93	20	91	34	94	51	95	49	92	50	86	40	76	25	68	11	51	—6
1846	67	10	55	0	69	20	88	27	91	43	91	46	96	57	92	64	92	44	81	28	73	15	66	19
1847	67	—3	60	5	72	14	86	26	88	36	92	47	92	54	90	52	89	38	83	27	75	19	60	2
1848	60	—4	60	17	86	5	84	31	90	40	91	50	90	58	92	61	87	40	75	36	59	25	73	24
1849	60	16	69	3	73	28	88	28	87	45	92	50	92	59	92	57	91	43	74	34	80	24	60	2
1850	61	7	72	0	71	22	86	25	89	36	95	44	96	65	93	60	90	44	83	31	77	25	65	11
1851	66	0	70	18	79	20	78	31	92	27	95	54	98	60	92	58	98	42	84	24	74	24	62	—4
1852	63	—12	60	15	85	14	89	30	87	39	91	46	98	59	89	58	91	42	87	35	69	27	58	21
1853	60	10	61	2	80	18	86	32	88	40	98	53	94	59	93	53	91	43	80	32	72	25	62	9
1854	70	5	68	16	80	22	91	28	92	42	94	45	95	64	96	58	99	46	83	35	65	24	58	15
Means	62	35	64	4	76	15	87	27.5	90	39	94	49	95	5[illegible]	93	55	91	41	81	28	71	18	61	8

ST. LOUIS, DR. ENGELMANN.
1849, 1850 and 1854 from the Military Record.

DATE.	Jan.		Feb.		March.		April.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.	
1833	..	..	..	..	82	—6	93	30	95	54	96	57	102	57	99	54	..	..	..	..	..	..	56	16
1834	57	—19	70	—2	77	16	93	24	95	41	100	49	103	56	108	57	97	38	84	23	79	16	57	3
1835	59	9	61	—25	70	8	..	..	..	..	98	37	98	50	..	..	..	..	..	..	..	..	..	..
1836	50	0	68	—8	70	7	89	29	97	48	99	56	98	61	94	52	93	46	87	24	70	16	53	—2
1837	55	5	67	16	68	18	87	25	86	37	87	56	96	62	96	51	93	48	85	29	81	24	72	7
1838	65	7	49	—5	85	26	93	30	86	38	94	43	101	62	98	64	91	43	87	25	71	10	59	1
1839	71	13	67	8	78	5	84	40	90	40	93	43	97	58	91	54	86	35	83	38	62	0	49	5
1840	49	—6	81	10	70	22	86	38	88	46	93	58	93	55	91	58	82	45	78	24	67	20	62	14
1841	60	—11	65	1	76	26	82	38	93	38	97	52	100	63	97	59	95	47	77	22	70	20	61	16
1842	66	20	67	2	86	28	87	43	88	42	95	45	96	54	95	52	98	44	85	35	78	7	64	4
1843	71	0	60	—1	55	7	93	25	91	42	97	46	98	59	97	58	97	53	83	26	71	24	63	13
1844	59	11	66	17	79	25	87	38	91	44	94	58	98	65	97	51	94	38	80	28	76	19	64	10
1845	65	23	73	16	79	20	91	24	86	43	95	56	97	58	93	61	95	47	79	28	71	0	53	—1
1846	61	21	52	2	75	20	84	31	89	50	92	53	97	57	94	60	93	53	83	30	69	19	65	18
1847	66	—1	66	2	76	12	84	30	87	41	88	54	94	55	89	56	92	45	88	28	77	21	67	4
1848	64	—4	73	11	78	0	82	35	91	43	90	55	95	59	94	58	86	43	77	34	63	17	66	5
1849	60	—2	54	—4	74	26	86	26	84	38	90	54	96	50	93	52	92	46	72	36	74	28	58	0
1850	55	14	66	—5	72	19	78	28	90	35	94	48	102	62	104	58	88	46	78	28	76	24	50	4
1851	63	1	69	14	78	23	76	34	92	29	92	54	97	54	94	61	94	37	81	27	64	25	65	—3
1852	65	12	66	14	82	19	81	29	91	42	94	47	95	57	90	55	91	42	88	42	61	20	60	15
1853	64	9	69	4	81	21	81	37	91	41	97	54	95	56	95	53	90	44	84	26	72	30	57	12
1854	60	—3	64	15	72	25	87	25	88	43	103	50	107	59	106	59	102	51	85	36	68	22	57	11
1855	65	3	67	5	67	14	93	32	93	38	95	50	96	60	91	65	90	47	81	28	71	24	65	—4
Means	61	4.5	65	4	75	16.5	86	31	90	41.5	95	51	98	58	95	57	92.5	45	82	25	71	18.5	60.5	7

FORT SNELLING, NEAR ST. PAULS, MINA.

DATE.	Jan.		Feb.		March.		April.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.	
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1822	46	-25	46	-20	63	14	83	22	84	43	89	54	92	60	89	56	83	35	80	15	63	-23	46	-29
1824	42	-24	43	-27	57	-10	73	25	89	27	85	54	96	55	92	53	84	42	68	25	57	-1	42	0
1825	38	-14	50	-15	61	21	82	34	83	42	83	54	92	64	89	59	79	43	82	20	69	10	40	0
1826	42	-23	50	-20	56	-4	60	4	89	36	92	56	87	33	87	54	78	40	82	26	60	17	48	-19
1827	44	-22	46	-8	56	-7	65	28	86	40	92	50	96	60	92	50	90	32	82	26	59	-3	33	-14
1828	38	-22	50	-22	56	-18	78	18	76	36	92	56	90	61	88	58	78	44	80	28	55	18	44	-3
1829	38	-18	33	-30	66	0	84	20	86	50	90	60	88	62	83	54	76	39	68	20	48	-7	46	-7
1830	33	-18	51	-19	54	2	66	33	80	32	82	48	94	70	90	61	79	37	82	36	65	27	53	-26
1831	32	-20	50	-20	58	4	79	26	88	39	84	54	92	61	92	51	80	34	82	19	59	-7	36	-26
1832	46	-26	36	-30	..	..	80	32	82	37	88	52	90	58	84	42	83	35	78	30	64	8	49	-11
1833	45	-17	47	-13	70	-20	80	27	86	42	90	40	93	58	85	53	81	41	62	19	58	14	45	-11
1834	40	-32	51	1	55	9	80	31	90	37	86	49	94	64	90	55	83	29	70	25	66	14	47	-8
1835	44	-16	49	-30	62	-9	77	22	81	41	88	49	92	54	89	51	76	35	76	17	60	-11	42	-12
1836	40	-26	52	-24	60	-16	77	20	84	40	88	50	93	63	84	50	74	40	64	20	56	14	48	-28
1837	40	-8	42	-10	48	-3	78	22	82	26	82	50	92	56	94	42	83	39	70	22	53	11	40	-10
1838	42	-21	30	-32	76	14	81	29	92	35	96	60	100	55	96	59	86	38	82	24	59	-4	40	-15
1839	42	-14	50	-26	72	-10	84	36	86	30	96	48	95	53	97	55	82	28	81	28	54	-3	45	-8
1840	40	-37	54	-20	59	0	79	22	92	41	89	55	88	54	85	52	78	36	71	19	58	-1	52	-6
1841	46	-32	60	-12	62	9	68	20	88	23	92	50	93	53	86	48	90	32	72	22	62	2	46	2
1842	49	-14	48	-22	69	2	86	26	83	28	81	38	91	41	89	46	86	35	76	22	67	-17	38	-12
1843	42	-18	30	-23	27	-20	70	1	72	27	89	35	90	50	81	61	82	32	65	10	39	5	39	-2
1844	38	-18	45	-15	65	4	80	30	76	32	83	41	87	55	85	44	81	33	71	22	59	-4	42	-8
1845	42	-12	47	-4	79	3	82	15	86	38	87	51	94	54	89	51	82	40	72	18	68	-12	46	-12
1846	59	12	52	-16	64	20	85	18	81	43	87	44	95	57	94	56	89	41	76	23	62	7	42	3
1847	34	-24	41	-16	74	-12	82	19	81	30	86	43	93	50	83	47	87	39	90	14	74	9	44	-19
1848	40	-24	44	-11	64	-10	76	20	82	39	90	42	88	50	86	48	79	34	70	31	44	-1	27	-15
1849	36	-29	40	-30	51	6	60	13	80	24	86	46	93	51	86	48	83	45	74	28	72	20	32	-22
1850	35	-16	43	-24	47	-5	74	17	86	31	88	35	98	59	90	52	80	47	70	31	57	15	30	-14
1851	44	-27	50	-12	76	7	79	20	79	29	87	43	94	53	89	49	92	34	76	20	62	9	46	-23
1852	44	-32	49	-13	57	-8	67	4	89	33	96	34	94	45	91	46	86	30	83	30	45	0	45	-24
1853	56	-15	45	-24	58	-15	67	14	84	33	86	49	82	54	90	43	90	41	73	8	54	8	47	-16
1854	45	-36	45	-20	58	4	85	9	84	32	93	41	93	55	95	50	88	39	74	28	60	11	45	-8
Means	42	-21	46	-19	61	-1.5	76	21	84	35	88	47.5	92	55	89	51.5	83	37	75	23	59	4	43	-12.5

FORTS KEARNEY AND LARAMIE:[1] FORT BROWN, NEAR MATAMOROS, TEXAS: LAREDO (FORT McINTOSH), TEXAS: FORT YUMA, COLORADO RIVER, CALA.: SAN DIEGO, CALA.: FORT MILLER, SAN JOAQUIN VALLEY, CALA.: SAN FRANCISCO: STEILACOOM, PUGET'S SOUND.

1849	28	-19	44	-22	70	7	80	22	78	34	87	50	92	45	88	38	88	34	74	24	66	13	59	-10
1850	57	-2	56	-7	59	9	78	21	89	26	91	49	92	54	100	47	93	40	85	14	66	6	44	-12
1851	60	-5	61	-1	70	15	81	15	85	30	90	42	102	53	99	56	89	47	79	20	65	13	51	-14
1852	60	-13	61	-4	71	-2	71	14	85	34	89	47	97	55	92	53	92	28	78	21	45	5	45	-11
1853	53	11	57	-4	71	9	71	32	69	33	88	49	87	59	94	55	91	36	75	20	66	22	68	13
1854	61	-21	62	8	65	21	78	24	80	38	93	48	92	54	94	58	85	50	87	30	70	18	64	10
1847	80	31	86	42	88	46	88	66	96	70	94	79	94	80	98	79	92	67	88	51	86	44	80	36
1850	79	44	87	38	86	42	92	52	86	56	92	70	93	73	98	75	96	71	98	54	84	46	86	22
1851	83	34	84	64	86	42	88	54	98	64	96	72	94	72	99	73	92	62	89	52	82	31	75	28
1852	78	22	90	49	89	45	97	45	96	67	99	67	93	73	96	74	92	64	92	50	84	46	80	42
1853	76	30	80	34	90	48	90	64	89	58	92	70	94	75	94	74	89	62	84	50	79	45	76	42
1854	80	30	84	40	86	47	90	52	90	67	96	72	98	74	92	72	90	70	91	60	85	44	85	34
1850	88	36	101	30	101	34	102	42	99	48	100	69	107	74	107	69	106	62	96	42	91	38	86	17
1851	87	29	84	36	100	33	103	49	104	56	106	70	104	72	106	70	102	62	96	49	91	23	88	23
1852	83	19	97	40	104	36	104	47	105	68	105	62	104	70	106	72	101	62	96	43	95	30	85	34
1853	80	28	85	28	96	35	102	46	108	57	105	66	108	72	107	72	102	56	95	44	91	34	79	32
1854	82	24	84	31	100	43	103	48	104	64	100	70	102	68	101	72	99	64	92	53	89	33	84	31
1851	82	30	82	19	92	32	100	54	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1852	..	..	..	..	..	..	..	..	..	..	106	68	108	70	108	70	104	60	98	50	88	38	75	32
1853	80	37	78	36	92	40	99	52	98	52	116	61	111	76	110	76	102	50	100	50	86	45	84	36
1854	79	26	80	32	87	37	101	46	101	46	113	59	113	77	109	77	102	68	105	52	84	46	73	42
1850	63	34	71	40	77	39	78	45	71	53	74	56	78	60	97	63	101	51	80	50	77	37	67	29
1851	80	32	67	34	82	34	..	..	..	..	..	..	..	..	..	..	..	..	..	..	78	37	70	36
1852	72	38	71	40	78	39	82	40	78	42	80	58	88	60	89	63	93	49	92	45	83	38	64	34
1853	74	35	75	36	84	38	86	45	78	45	84	56	88	61	90	56	99	53	99	46	78	40	71	37
1854	78	31	71	35	69	36	93	44	78	39	93	48	99	56	94	56	96	52	87	44	84	46	74	31
1851	..	..	..	..	..	..	..	..	..	..	..	..	..	..	111	62	100	56	98	46	88	37	64	32
1852	63	32	74	36	85	29	101	38	113	41	116	68	..	..	113	55	114	50	96	41	84	34	72	28
1853	68	28	73	32	83	34	95	40	102	50	121	51	118	59	113	54	102	50	97	45	79	39	68	34
1854	64	23	67	32	74	33	83	45	88	46	102	53	115	63	..	..	99	54	97	46	80	34	65	35
1850	..	..	..	..	77	37	76	44	66	50	70	49	74	49	74	50	94	43	78	42	74	38	64	28
1851	64	33	71	33	74	34	84	42	71	45	78	49	73	47	82	50	75	50	83	47	73	41	61	35
1852	64	35	84	30	80	36	..	..	..	..	..	..	69	55	68	50	90	47	69	46	70	41	63	37
1853	62	39	67	42	77	41	75	46	81	47	84	49	78	50	76	51	88	50	85	49	73	44	69	40
1854	69	25	69	38	72	38	83	45	73	43	74	47	87	46	85	50	87	46	83	46	72	47	71	38
1850	47	23	56	22	62	30	70	38	74	38	84	46	86	50	84	44	84	40	74	30	56	27	50	20
1851	58	23	56	24	60	26	74	31	80	40	84	46	92	46	92	48	76	40	67	39	63	29	52	22
1852	60	25	58	29	69	19	62	26	90	38	93	41	87	49	87	45	85	28	68	35	59	28	48	0
1853	55	25	54	20	62	24	67	34	84	35	83	47	94	44	93	43	83	38	78	29	59	27	60	23
1854	58	-1	60	22	67	30	78	32	84	40	86	44	93	45	94	45	83	40	74	30	60	32	58	26

[1] 1849 and 1850 at Fort Kearney, at which the extremes are usually the same.

MEASUREMENTS OF RAIN FOR SUCCESSIVE YEARS.

NEW BEDFORD, S. RODMAN, *MS.*

DATE.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1814	1.26	7.38	1.92	4.85	3.76	2.02	0.88	5.73	2.72	1.54	4.77	1.47	38.3
1815	4.05	2.98	4.46	4.14	3.65	1.97	1.74	3.88	2.23	1.31	3.07	2.80	36.7
1816	1.88	6.06	2.20	4.89	5.47	2.07	0.90	1.30	5.38	3.52	4.94	0.62	39.2
1817	3.52	4.68	1.57	2.31	1.06	6.22	0.78	2.85	3.64	1.06	5.90	4.93	38.5
1818	2.94	0.81	2.94	3.50	6.04	3.12	2.95	1.48	4.91	2.52	2.98	2.05	36.3
1819	1.11	2.26	6.49	2.94	1.83	2.95	1.40	5.33	4.28	3.41	1.71	1.55	35.3
1820	1.30	4.46	3.95	1.09	4.81	0.41	3.30	3.89	1.79	5.53	3.33	2.87	36.7
1821	2.06	5.30	2.24	5.41	4.82	3.36	2.14	1.98	3.66	4.41	2.61	2.58	40.6
1822	2.92	3.29	2.94	4.23	0.51	2.29	4.57	3.12	5.39	2.64	3.22	2.02	37.1
1823	4.30	4.45	7.49	1.62	6.82	2.84	4.12	3.47	1.85	4.50	3.12	8.66	53.2
1824	3.41	4.73	3.21	5.10	2.38	2.79	2.17	5.52	4.34	2.27	3.15	3.01	42.1
1825	2.49	1.96	5.39	1.26	1.88	3.30	1.83	3.13	1.49	2.47	1.61	7.05	33.9
1826	1.95	3.42	3.63	2.59	0.65	1.88	2.17	1.66	1.28	6.64	4 00	3.84	48.7
1827	2.79	3.55	4.34	3.08	6.17	3.93	3.87	6.78	5.02	5.94	7.48	2.96	55.9
1828	2.68	2.89	3.83	3.09	3.48	3.59	2.69	1.02	3.23	3.22	4.58	0.40	36.0
1829	8.05	5.12	6.25	4.26	7.64	2.60	3.02	6.69	3.10	3.14	6.38	1.89	58.1
1830	3.73	2.73	4.24	2.00	5.89	3.30	10.67	5.53	4.62	3.15	5.49	6.13	57.5
1831	6.64	3.14	4.66	6.56	3.96	3.13	6.45	2.95	5.21	5 37	3.27	3.05	54.4
1832	3.54	4.77	2.68	3.03	5.82	0.37	1.50	7.38	2.67	2.35	3.93	5.79	43.8
1833	3.47	2.11	1.71	2.05	2.68	3.78	1.23	2.28	1.67	5.07	4.90	5.94	37.9
1834	2.45	1.43	1.74	2.62	4.21	6.49	3.04	1.61	5.00	4.67	3.76	3.09	40.1
1835	2.98	1.60	5.80	6.07	2.36	2.24	1.39	9.03	0.80	2.66	2.64	4.40	41.9
1836	8.47	4.11	3.36	2.47	1.56	4.38	1.69	1.00	1.14	2.29	4.03	3.57	38.1
1837	3.28	3.33	3.97	2.96	5.75	3.93	1.91	3.89	0.48	1.19	1.33	2.71	34.7
1838	2.67	2.14	2.58	1.91	2.68	2.53	1.38	2.66	5.96	4.78	3.88	0.86	34.0
1839	0.68	2.41	2.17	4.29	4.41	2.23	2.45	5.24	3.00	5.21	1.79	5.56	39.4
1840	2.89	2.38	3.55	4.05	5.17	3.28	1.90	2.56	2.73	6.16	6.69	2.72	44.1
1841	4.95	1.56	3.61	8.24	1.48	1.28	2.71	4.49	2.58	4.18	4.71	5.19	45.0
1842	2.19	3.86	2.57	3.35	2.82	6.58	1.19	1.75	1.78	0.77	2.72	5.15	34.6
1843	3.50	3.72	3.57	5.50	1.24	1.29	2.94	6.34	1.57	6.10	4.52	4.75	45.0
1844	3.72	1.94	5.91	1.58	2.31	0.83	2 74	2.21	3.69	4.05	3.56	3.67	36.2
1845	3.70	2.67	2.70	1.66	3.35	2.08	2.75	3.01	3.99	3.81	8.64	4.36	42.7
1846	2.75	2.28	1.55	1.07	5.69	0.68	2.32	2.73	2.20	1.49	3 38	4.34	30.7
1847	2.96	4.06	2.89	1.48	2.35	5.74	2.14	6.36	6.40	0.55	1.35	4.53	40.8
1848	3.33	3.75	2.57	1.30	3.45	2.66	3.59	1.03	1.68	4.83	2.93	5.09	36.2
1849	0.78	1.84	5.07	1.98	2.16	1.41	1.08	4.34	1.10	5.08	4.58	2.95	32.4
1850	5.22	1.47	5.38	4.30	3.99	1.09	2.01	5.59	10.72	2.33	2.51	6.67	51.8
1851	1.99	5.51	2.91	8.22	4.25	1.05	8.20	3.10	3.33	4.77	4.23	2.23	49.8
1852	3 48	3.17	4.89	6.99	3.11	1.52	2.27	4.88	1.79	1.80	3.24	3.87	41.0
1853	1.50	4.15	1.14	3 48	3.88	0.82	3.51	2.62	3.41	3.12	3.49	3.95	35.1
1854	1.77	5.04	1.91	6.07	3.17	2.69	6.61	0.21	7.44	1.32	8.59	3.02	47.8
1855	4.20	2.33	1.73	3.77	1.23	1.63	4.26	1.26	0.55	4.14	4.29	5.05	36.4
1856	4.61	1.13	1.46	2.85	3.52	1.88	..	..	..	..	..	..	..

NEW YORK, FORT COLUMBUS.

1836	1.09	2.01	1.31	2.66	0.63	6.46	1.44	2.37	3.40	2.00	1.90	2.30	27.57
1837	2.70	3.70	8.20	7.50	9.50	8.50	5.90	6.30	2.10	2.11	2.90	6.10	65.51
1838	3.93	3.70	4.10	2.50	3.99	3.12	1.83	4.79	4.96	3.64	3.10	2.24	41 90
1839	0.69	2.05	2.46	3.35	8.37	4.94	1.35	4.92	3.59	1.45	2.19	7.61	42.97
1840	1.84	1.84	2.92	2.03	2.39	2.40	1.80	4.25	1.84	4.59	2.90	1.00	29.80
1841	5.30	0.80	2.35	3.93	3.95	4.65	4.90	2.50	2.90	4.40	3.70	2.70	42.08
1842	1.07	2.85	1.25	3.60	3.60	3.30	3.80	2.81	2.10	4.30	1.80	3.50	32.98
1843	1.00	2.31	2.13	2.14	1.00	0.76	1.64	15.26	3.06	5.91	2.82	3.34	41.37
1844	2.66	1.03	4.50	0.55	3.41	2.37	6.00	2.73	4.50	4.08	1.73	2.82	36.38
1845	4.87	3.22	3.33	1.22	1.75	3.70	1.75	3.21	2.62	2.50	3.40	2.51	34.08
1846	3.92	3.01	3.82	4.01	9.70	1.39	6.01	3.88	0.48	1.34	8.36	2.99	48.91
1847	4.62	5.74	8.48	1.53	2.18	6.78	1.62	6.93	12.20	2.13	6 29	6.35	64.85
1848	1.75	1.68	2.23	1.16	7.28	4.56	2.64	1.41	1.87	6.61	1.59	4.02	36.80
1849	0.61	2.26	4.87	0.62	3.47	0.78	1.43	4.63	1.55	5.63	1.88	4.01	31.74
1850	5.57	2.64	4.64	2.72	9.20	3.07	3.92	7.21	4.71	3.16	2.33	5.36	54.56
1851	1.46	4.50	1.70	6.94	4.73	0.90	4.72	3.47	1.26	2.95	4.53	3.72	39.97
1852	2.92	3.08	4.43	4.74	2.24	2.11	3.25	6.20	2.29	2.06	6.07	4.45	43.84
1853	4.14	4.98	2.03	3.32	5.80	4.80	4.40	5.50	5.49	3.90	6.80	1.04	52.20
1854	2.60	4.00	0.70	8.80	7.70	2.20	1.90	1.03	1.90	1 80	3.95	8.60	45.18

GETTYSBURG, PA.; PROF. JACOBS, *MS.*

1839	3.38	1.73	0.84	2.40	3.39	4.83	4.52	6.13	2.39	0.83	2.65	4.97	38.01
1840	2.46	1.98	2.52	3.94	2.64	2.38	1.00	2.90	1.54	7.12	2.18	3.66	31.77
1841	6.35	1.45	5.37	4.68	3.43	2.89	2.62	3.00	4.15	1.52	3.92	6.06	45.43
1842	1.73	1.92	2.74	5.78	3.24	4.15	2.69	4.13	0.94	2.30	3.90	2.71	36.24
1843	3.25	2.55	4.82	3.24	5.23	1.86	3.60	4.51	8.71	3.25	3.52	3.09	47.63
1844	3.19	1.56	3.47	1.79	3.99	2.36	3.32	2.46	2.55	3.67	1.45	1.66	31.17
1845	2.70	2.34	2.79	2.41	1.10	4.57	0.93	1.87	0.72	6.18	2.22	2.35	30.1
1846	4.23	2.66	4.93	2.95	5.78	6.20	4.46	4.39	1.24	3.89	8.48	3.07	52.28
1847	4.08	5.57	2.40	0.65	2.51	2.00	4.72	2.87	8.37	5.82	5.81	6.08	50.89
1848	1.83	1.20	3.54	0.62	2.42	2.28	5.38	4.14	1.54	2.73	3.15	4.78	33.62
1849	0.98	2.57	3.64	1.03	4.33	1.85	2.45	1.91	0.86	5.79	0.94	5.18	31.54

GETTYSBURG—Continued.

DATE.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1850	5.57	4.67	3.89	3.72	5.42	2.04	4.74	2.17	3.78	2.93	2.05	4.65	45.71
1851	0.63	2.66	3.77	3.64	2.31	1.16	4.26	2.51	1.95	2.19	3.72	2.19	30.98
1852	2.49	2.70	4.15	5.93	3.49	3.55	1.85	4.72	1.98	1.74	6.47	4.24	42.32
1853	1.74	3.23	1.29	4.48	2.87	0.26	5.67	3.38	3.89	2.79	1.47	1.01	31.09
1854	3.26	3.60	1.90	5.37	3.31	2.84	1.62	0.90	2.46	2.27	3.63	2.70	32.86
1855	3.57	2.41	2.04	2.08	1.69	7.72	3.79	10.88	5.92	2.22	1.27	4.01	47.62
CHARLESTON; Lining and Chalmers; Dawson.													
1738	1.10	4.42	4.53	1.08	3.13	1.57	10.66	4.10	10.79	1.36	2.66	3.88	49.25
1739	2.31	2.87	5.61	0.19	5.12	15.84	4.45	12.21	4.83	6.59	1.24	3.69	65.96
1740	4.87	3.08	1.14	1.09	5.61	4.65	3.01	7.30	3.20	1.29	1 85	2.74	39.81
1741	4.49	4.62	5.71	1.31	4.84	5.54	3.40	7.14	6.73	3.40	2.96	1.92	52.07
1742	2.19	1.65	5.20	0.92	5.90	3.25	1.25	7.65	2.90	0.76	3.39	0.96	36.02
1743	3.17	2.43	0.62	5.29	2.54	1.90	7.74	3.77	4.66	1.67	3.22	2.71	39.76
1744	1.99	3.06	0.58	2.87	2.87	5.81	8.44	4.20	5.66	1.59	1.56	9.68	48.33
1745	0.86	7.74	3.23	3.84	1.83	9.51	6 77	9.34	0.75	2.96	0.68	2.62	50.14
1746	1.15	2.70	1 63	1.13	3.99	4.11	9.89	6.11	0.93	0.51	3.58	3.92	39.66
1747	3.43	2.86	2.59	0.29	0.92	2.47	6.41	4.89	7.22	9.50	1.06	2.92	44.57
1748	2.11	1.57	3.05	0.98	1.82	1.86	9.27	6.88	7.44	5.55	5.37	5.59	51.50
1749	1.06	4.52	7.48	1.76	5.35	4.69	6.22	11.12	1.30	3.90	1.24	5.60	54.42
1750	2.56	3.13	0.94	2.31	2.37	8.69	5.69	5.34	12.37	5.00	3.14	4.61	56.07
1751	0.00	5.37	1.34	2.30	5.53	2.46	6.54	12.14	11.67	0.35	0.68	2.41	50.80
1752	3.60	0.80	1.71	0.44	2.79	2 62	1.48	10.72	14.66	1.20	0.81	2.03	42.88
1753	2.11	3.82	3.78	0.17	4.60	2.79	8.48	7.67	4.82	4.92	3 10	1.10	47.36
1754	0.86	1.83	1.23	0.44	0.00	1.84	8.87	8.67	3.76	1.45	3.09	4.18	37.22
1755	1.28	1.41	1.41	4.31	2.29	7.15	6.48	9.75	0.67	3 39	2.18	2.97	43.29
1756	2 73	1.10	3.52	4.31	1.19	5.33	1.69	5.21	1.12	3.74	0.62	1.13	31.69
1757	4.80	2.90	3.41	2.16	2.66	4.78	10.87	3.20	7.72	0.46	0.64	0.84	44.44
1758	0.53	0.53	1.76	0.19	4.71	4.49	1.72	4 56	3.01	5.35	1.83	1.94	30.62
1759	1.86	2.10	1.89	2.50	3.10	1.89	3.15	5.55	6.81	3.79	2.63	1.10	36.37
1841	4.49	3.00	7.25	2.36	0.72	4.52	5.31	16.90	3.85	2.73	1.12	1.99	54.24
1842	0.54	2.79	0.05	1.56	4.69	4.39	9.17	6.48	3.12	3.54	2.35	3.41	42.09
1843	1.52	1.28	12.14	0.65	3.22	3.59	8.96	9.68	8.11	2.60	0.77	2.20	55.72
1844	2.21	2.33	4.20	1.50	2.14	1.80	0.45	7.38	4.95	1.53	5.40	2.50	36.39
1845	3.65	1.20	2.72	0.10	7.62	1.69	8.02	9.42	2.27	5.51	0.62	3.62	46.44
1846	4.46	3.79	5.72	2.43	2.53	5.24	4.32	8.24	3.03	2.44	0.56	1.58	44.33
1847	1.65	2.80	6.54	0.77	6.91	3.00	9.26	9.21	4.28	0.72	0.72	1.97	47.83
1848	0.73	2.73	0.17	2.97	4.62	3.40	4.73	4.59	4.62	9.05	1.67	4.12	43.40
1849	0.23	1.36	0.80	0.22	3.53	1.64	6.35	5.16	6.27	3.91	0.23	0.99	30.69
1850	2.16	1.94	5.17	2.10	2 64	0.14	0.66	4.56	1.17	0.58	0.63	1.94	23.69
1851	3.08	0.85	0.97	1.19	0.58	9.76	6.32	5.44	0.46	0.86	2.50	1.13	33.14
1852	0.62	0.81	3.57	4.50	4.22	5.18	6.93	4.21	12.27	1.16	1.93	4.32	49.72
1853	1.07	2.00	2.77	0.11	1.61	3.83	10.06	3.58	10.62	2 87	3 12	1.84	43.48
1854	2.87	2.99	0.87	1.04	5.29	4.18	6.62	1.56	8.73	1.33	1.09	1.05	37.62
KEY WEST, W. A. Whitehead; Mil. Post.													
1833	2.20	1.50	0.50	0.85	3.35	1.90	4.30	3.10	4.45	1.03	2.07	2.30	27.55
1834	0.33	0.00	1.96	1.75	11.46	0.10	2.70	3.46	3.80	8.85	1.67	0.01	36.09
1835	2.40	0.00	0.05	1.15	3.61	3.15	3.25	5.93	5.90	0.43	1.43	2.77	30.07
1836	2.35	1 17	1.45	0.60	6.95	4.40	1.10	0.70	3 25	1 65	0.52	0.25	24.40
1837	1.83	0.92	0.75	2.42	5.35	1.67	1.65	7.50	5.80	6.05	3.05	1.65	38.66
1838	0.05	0.05	0.00	0.02	0.82	4.86	1.15	3.05	3.47	0.40	5.75	0.87	20.49
1850	..	..	..	..	..	..	2.02	3.38	3.93	4.18	0.01	2.10	..
1851	2.40	0.88	1.50	1.80	5.32	9.24	3.24	6.80	14.00	9.45	2.30	2.64	59.57
1852	1.82	3.67	8.74	2.17	0.40	8.51	6.16	6.03	6.22	4.18	3.00	3.41	54 31
1853	2.80	0.35	12.06	..	0.94	18.11	2.33	5.02	4.39	1.69	1.08	0.89	49.66
1854	1.77	2.55	0.51	2.99	3.14	4.54	3.45	5.83	9.70	4.73	0.25	8.45	47.91
1855	3.94	0.83	2.87	0.24	3.55	4.47	..	..	..	..	..	..	..
FORT SNELLING.													
1836	..	..	..	..	..	..	7.28	5.55	4.45	0.55	0.70	0.63	..
1837	0.27	0.35	0.33	0.95	2.65	3.46	2.73	1.32	5.10	3.15	1.37	2.34	24.02
1838	0.65	0.75	0.15	2.41	3.05	4.76	11.11	3.08	0.71	0.16	0.43	0.45	28.22
1839	1.34	0.36	0.71	2.71	3.28	1.80	3.50	1.04	1.61	2.11	1.66	1.07	21.19
1840	0.49	0.49	0.65	1.55	2.31	3.50	2.89	3.40	2.33	2.21	3.22	0.13	23.00
1841	0.24	0.21	1.43	1.40	1.50	4.24	1.57	1.17	6.10	1.55	0.84	1.42	21.67
1842	0.95	0.72	0.44	2.17	1.68	3.73	1.78	4.81	4.83	..	3.46	0.60	..
1843	1.15	1.46	0.82	0.75	3.12	5.22	2.69	1.84	5.14	0 50	1.43	0.27	23.09
1844	1.50	0.72	0.97	5.16	4.60	1.64	4.80	4.37	4.26	0.97	0.77	0.58	30.14
1845	0.49	1.40	2.80	3.15	1.51	6.80	2.56	3.28	2.21	0.66	0.40	0.08	25.34
1846	0.52	0.03	1.71	2.90	2.00	3.10	4 95	3.80	2.33	2.45	2.10	0.21	26.10
1847	0.29	0.11	0.44	0.45	4.96	2.66	3 66	2.49	4.00	0.37	1.71	0.66	21.80
1848	0 62	1.13	1.71	0.18	5.28	2.83	4.60	3.19	2.46	0.68	0.10	0.40	23.18
1849	1.00	0.61	4.11	5.62	6.57	3.14	7.59	9.60	2.75	5.35	1.40	1.95	49.69
1850	1.67	0.83	2.23	2.60	0.58	4.62	6.15	2.97	1.82	0.32	1.68	0.04	25.50
1851	0.20	0.13	1.23	2.68	3.96	2.15	2.60	3.29	3.64	1.18	2.31	0.05	23.42
1852	0.06	0.14	2.04	2.49	4.72	0.08	2.74	0.89	0.72	0.82	0.22	0.15	15.08
1853	0.00	0.01	0.02	0.73	4.08	7.59	1.65	2.57	2.14	0.01	0.56	1.11	20.47
1854	0.72	0.03	1.03	2.51	4.30	3.31	3.92	1.75	6.55	1.23	0.60	0.64	26.59
1855	1.67	0.41	1.84	0.28	1.23	2.36	..	..	..	..	..	..	..
Means	0.73	0.52	1.30	2.14	3.17	3.63	4.11	3.18	3.32	1.35	1.31	0.67	25.43

II. CLIMATOLOGICAL FEATURES OF SURFACE AND CONFIGURATION: PHYSICAL GEOGRAPHY.

THE collection of materials for the Physical Geography of the area of the United States, or of the temperate latitudes of the continent, is now nearly complete, though an intelligible view of the surface character and vertical configuration of the western and interior districts is among the most recent of results. Previous to the admirable surveys of Fremont, the explorations of Lewis and Clarke,* and the

* The early American surveys were all very ably and successfully conducted, and some note of their date, and of the auspices under which they were undertaken, may be of service in this connection. Those directed to the interior beyond the Mississippi, began with the sending, by Pres't Jefferson, of Capt. Meriwether Lewis (1st Infantry) and Lieut. Clarke, "to explore the Missouri River to its source, to find the shortest passage of the Rocky Mountains, and to seek the best water communication with the Pacific Ocean." This was in pursuance of a measure proposed by Pres't Jefferson, in a message to Congress, Jan. 13th, 1803. The report of the results was transmitted by the President to Congress, Feb. 19, 1806. It comprised what is yet the most valuable and accurate map of the great plains of the Upper Missouri.

In 1805, Lieut. Pike was sent by Pres't Jefferson, to explore the Upper Mississippi. He left St. Louis, Aug. 9, 1805, and returned 30th April, 1806. He established the general geography of that region, which was subsequently verified and filled up by Nicollet and Pope.

In the same year, 1806, Lieut. Pike was again sent out, with orders to trace the Arkansas River to its source, and then to seek the sources of Red River, &c.; but he did not find Red River. Extending his journey to the sources of the Rio del Norte, in New Mexico, he was taken prisoner there, and sent back by way of the Gulf of Mexico. He left St. Louis for this survey, July 15, 1806, and returned July 1, 1807. Much of the geography of that district was correctly indicated by this able survey; Pike's Peak retains his name.

Major Stephen H. Long, Top'l Engineer, was sent by Mr. Calhoun, when Secretary of War, in 1819–20, on a survey from "Pittsburgh to the Rocky Mountains." He had a well organized corps, embracing Lieut. Swift, and Lieut. J. D. Graham for some portion of the conclusion. They established "Engineer Cantonment", "3 miles S. E. of the point called Council Bluffs," on the Missouri, at the close of May, 1819; and instituted regular meteorological observations, which were continued for several years at the military post on or near the spot. In the report it is said: "The Rocky Mountains may be considered as forming the shores of the sea of sand, which is traversed by the Platte, and extends northward to the Missouri, above the Great Bend."

Maj. Long's second expedition was to the source of the St. Peters River, in 1823.

surveys of Pike, Long, and Nicollet, were wanting in material to connect the parts in the sense of physical geography, and some of the most important points then indicated rudely, but now well known, were received with much doubt, and failed to be incorporated in European representations. Then followed Major Emory's surveys, Stansbury's survey of the Great Salt Lake, and others, and last the magnificent system of surveys for a Pacific Railroad in 1853, 4, and 5, completing our knowledge of the whole region, and defining the districts and special lines traversed in a manner to leave nothing desired. The portion of the Basin region not reached by any of these surveys lies mainly below, or south of the valley of Humboldt River, though there is a small tract north of that river yet unvisited; but for general purposes, it is probable that both these tracts are very well defined by the lines already passed over, and now known. They are only portions of the arid interior basin, which is well known at its southern and northern borders, and at its passage by Humboldt River. The rough country of the Great Colorado of California, is also unknown in parts, though the three lines by which it has been traversed, probably correctly represent the whole.

The great point of interest lies in the new features of our physical geography, or in the views which differ so far from those previously held, as to require a change in all deductions based upon surface and vertical configuration, as all those of climatology must be to some extent. The most important of these recent determinations is that of a much greater altitude for the western interior than was before assigned to it, and that high and arid plateaus and basins exist in nearly as great a proportion to the general area of the continent as in Asia and Europe. There are conditions of surface and configuration similar to those which have been thought peculiar to Europe and Asia belonging to great regions here, and we are to look for

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Mr. Colhoun was astronomer, and Prof. Wm. Keating geologist and historian. They gave the geography of the district west of the Mississippi only, taking Pike's results for the Upper Mississippi.

J. N. Nicollet's surveys began in 1836, and were variously continued to 1840, assisted during the last three years by Lieut. Fremont. His standard map of the Hydrographical Basin of the Upper Mississippi was completed in 1843.

Fremont's first expedition was in 1842, to survey the district of the Platte and Kansas Rivers to the base of the Rocky Mountains. In 1843–4, his second expedition was undertaken, traversing almost every part of the country beyond the Rocky Mountains, and discovering and defining the Great Basin. In 1845–6, his third survey was made, through the Great Basin, and on the eastern slope of the Sierra Nevada, entering California near Kern River, and again traversing various points of the Sierra along its western slope.

Maj. Emory's surveys south of this district, and in New Mexico and California, began in 1846, and various less important surveys rapidly succeeded.

correspondence in climate, and in vegetable and animal life, and if this last does not now exist, we ascertain such a correspondence to be possible, and may adapt our practical interests accordingly. Guyot,* and other writers on physical geography, have contrasted the temperate latitudes here with those of Europe and Asia in the view that this is wanting in the high desert plateaus of that, and assuming for this less altitude, a greater proportion of plains, and, consequently, the analogies of sea climates in contrast with the extreme continental peculiarities of Asia. Our recent surveys have shown that lofty plateaus, lofty mountains, and extended districts of the most extreme continental character, exist here in nearly the same relation to the whole mass of the continent as in the old world, and the comparison of the two thus becomes much more direct and more necessary than before, as essential to a proper understanding of our climatology. In short we may compare the two as mainly equal and similar in the physical features of surface and configuration, and we must do so to correctly estimate the consequences upon climatology, which are always most directly dependent on physical geography.

Some detailed description of the surface of the United States is perhaps necessary, and it may now be given for every part of the territory. Most of the surface of the eastern portion is but little elevated above the sea, and quite uniform in its character. It is all wooded in its natural state, and all cultivable, with equally distributed rains; and therefore little, in regard to climate, depends directly upon the surface character. It will be elsewhere shown that the presence of forests, or their exchange for cultivated fields, are not primary conditions or causes in climatology, and as the question whether the removal of forests effects any changes belongs to the consideration of permanence of climate, it will here be assumed that the surface condition in this respect is a consequence, and not a cause. We have only the simple element of altitude to consider in the Eastern United States in this connection, and all the highlands belong to the Appalachian system or Alleghanies, the several parallel ridges of a broad belt being included under this general name.

It is singular that for the whole of this belt the elevations are not high enough, or the ranges not sufficiently continuous where high

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* *Earth and Man*, Comparative Physical Geography. Fremont remarks with great force the impression produced on his first determination of the character of the Great Basin. "The whole idea of such a desert is a novelty in our country, and excites Asiatic, not American ideas. Interior basins with their own systems of lakes and rivers, and often sterile are common enough in Asia. . . But in America, such things are new and strange, unknown and unsuspected, and discredited when related." (Exped'n of 1843–4).

peaks are found, to cause any contrasts in climate on their opposite slopes. These slopes are everywhere equally well watered, and equally clothed with forests; and neither differs in any important degree from the plains in its vicinity. Though some importance was for a long time attached to positions respecting these slopes, this importance now fails by common consent, and we scarcely regard the Alleghanies as disturbers of any condition of climate, except in the moderate degree produced by altitude alone, as they are ascended. There is, in many cases, a contrast of positions, scarcely less than those of the coast ranges in California, but the extreme differences which there belong to opposite sides of low ranges are here unknown. The interior valleys of the Alleghanies are nearly as warm as the great body of the country at either side, and though the temperature and quantity of rain diminish in a moderate measure, neither does so in a degree so great as to entitle the mountains to the important place, as climatological agencies, which mountain ranges in Europe and on the Pacific coast invariably have.

North of the 41st parallel, the highlands of the Alleghanies have probably more rain than the plains, and there are two or three considerable areas lying at twelve hundred to fifteen hundred feet above the sea. The climate of these areas is modified only by diminution of temperature, and by some increase of humidity, however; no positive change beyond these occurs. A small area in New York, with one in New Hampshire, may probably be put at 3000 feet elevation, but these differ from other highlands only in degree of the last mentioned changes; the forests and general climate remain as before until by gradual transition they pass into Alpine forms at the height of 4000 feet.

Analogies like those of California, would make the inner valleys of the Kanawha River in Virginia, and of Lake Champlain in Vermont, partial deserts; and the fact that these two deepest interior valleys, whose position is also nearest the mountain ranges of greatest elevation, are uniform in humidity and temperature with other districts of like elevation—differing little, indeed, from the sea-shore at the same latitudes—is conclusive evidence that the configuration of this part of the United States, has far less influence as a climatological agency than a similar configuration would have in Europe and on the Pacific coasts.

In New York there is a mass of mountains in the north, and a high plateau stretching south and west, through the whole extent of the State. This is from one thousand five hundred to two thousand feet above the sea, with single groups of mountains a thousand to fifteen hundred feet higher; and yet this very considerable mass has but a moderate effect on the humidity and quantity of rain, and it only

reduces the temperature by the average European rate, or, perhaps, a degree for three hundred feet of altitude. The valley of Lake Ontario appears to be somewhat influenced by its relation to the highlands, as it has somewhat less rain, and a larger share of clear weather. Perhaps there is a similar result at Lake Champlain, but in each case the differences are small, and the distinction is not particularly important. These remarks relate, of course, solely to the general influence of the hills and mountain ranges, and there are isolated peaks and summits where some form of precipitation is almost constant. The summit of Mount Washington is the most conspicuous of these, and there are several in the same group of mountains which approach it in the constancy of cloud formation, and deposit of rain. Several summits of the group called Adirondack Mountains in northern New York, are obscured by clouds with great constancy at some seasons, and even the Catskills show decidedly greater prevalence of clouds in the colder months, than the table lands of the vicinity. The view from Mount Washington at 6800 feet elevation, is almost constantly obscured, and violent gusts and dashes of hail and rain occur there, when it is perfectly calm and clear below. It may be mentioned, incidentally, that the violence shown at these instances of purely local precipitation renders it easy to explain the violence of winds in general storms, when the greater mass of the atmosphere participates in the changes.

The uniformity of surface over an area so great as that from the 95th meridian eastward is quite important, and it is a fact not less so that the elevations of the Alleghanies have so little influence in interrupting the uniformity of the conditions in climatology. Their southern extremity, though more elevated than the northern, still modifies the climate very slightly, and this, as before, only directly, or for the absolute spot itself. No valleys are overshadowed, and no plains influenced on either side; and none of the contrasts exist which are so conspicuous in Eastern climates of like temperature, as the north of Italy, Tartary, Persia, and the north of India.

In extending this notice of vertical configuration to the western side of the continent before referring to continental outlines, we find west of the Mississippi some minor mountains which are analogous to the Alleghanies in the Ozark Hills, and others at the southwest of these. Their climatological influence is not great in any case, and it is probable that they stand in the same relation to the great district in which they lie that the southern branches of the Alleghanies do. They are slight interruptions of the uniformity of the great plain of the Mississippi, which is conspicuously *plain* and not *valley*, and which is itself a feature of interior configuration found in no other portion

of the temperate latitudes. If the interior plain of central Europe opened out into tropical climates at the south without the intervention of the high mountain districts of Turkey and Asia Minor, there would be a parallel configuration in many respects, but now the interior plain of Europe corresponds more nearly to that of British America than to the Mississippi valley proper. The river beds of the whole area usually called by this name lie in slight and abrupt depressions, and not at the foot of slopes, and this fact is significant of its original formation as a plain.

The Lake district is also a great plain, and, with few exceptions, it is all such to the polar seas. On both the north and south of Lake Superior there are mountains of moderate height, and over a line northeastward from this lake to the mouth of the St. Lawrence, there are ranges of granite hills, always low, yet more or less lifted above the average surface. All these are but hills, indeed, yet the high latitude and interior position of those near Lake Superior gives them as much climatological importance as the central portions of the Alleghanies have. They retain their forests like all the rest, and only reduce the temperature, and add something to the quantity of rain.

Passing this great area of uniform characteristics, we rise on the plains west of the Mississippi at a very low rate of ascent, and come upon great changes of soil and surface materials. At the 100th meridian, and at two thousand feet elevation, the arid and sandy surface begins, with its climatological associates of variable temperature and great aridity of atmosphere; though there is yet no reduction of mean temperature. At the 105th meridian an elevation of over five thousand feet is attained, along a line from the southern limit of the United States to latitude 44°, and so far coincident with that meridian; but here this line turns abruptly northwestward to conform to the general trend of the Rocky Mountains, reaching 110° and 112° west longitude at the northern boundary of the United States. This is the highest and most arid part of the plains, and it lies at the foot of the mountains, the last five degrees of longitude having brought us over a surface of entirely uniform slope, yet increasing rapidly in altitude and in aridity. Sandy and saline tracts are interspersed over all this surface, yet none of them are of an extreme desert or basin character, like those beyond the mountains, or in the interior of Asia. The surface is much like that in the vicinity of the Caspian Sea, and of Mongolia at the west and south; districts having a large population and much capacity for cultivation.

The great chain of the Rocky Mountains is next in the surface configuration, and from this point forward all the uniformity belonging to the Eastern United States disappears, and the greatest and

most abrupt contrasts occur. As in the north of India, and in other parts of Asia, everything here depends on configuration and surface; and not only on these directly, but also on the relation of any point or locality to an extreme of configuration in the vicinity. Thus the valleys of California are mainly controlled by the mountains near them, and if shut from the sea have arid climates, and, perhaps, a denuded, sandy, or alkaline surface; when, if open to sea influences, the reverse conditions prevail. These remarks apply more particularly to Oregon and the coasts north of the 35th parallel, than elsewhere, as the coast of Lower California is arid at all exposures.

The most important point in the vertical configuration of the Rocky Mountain region is its plateau character, or the great altitude of the base line from which the mountains rise and the valleys fall. In this sense, the average of the whole continent west of 102° of longitude might be taken as on a base five thousand feet above the sea, excepting only the immediate coast of the Pacific and the deeper valleys of California. A better division would be to take the Rocky Mountain plateau at six thousand feet, and that of the Great Basin at four thousand; still throwing out some exceptionable districts at the extreme points north and south. The Rocky Mountain plateau is best defined at the vicinity of the South Pass, yet it extends from Fort Owen to El Paso with an average breadth of five degrees of longitude at least; more correctly, perhaps, an average of two hundred and fifty miles. In latitude, it is nearly one thousand miles in extent, giving an area of two hundred and fifty thousand square miles for this lofty plateau. The sharp mountains interrupt these irregularly rather than regularly, and the characteristic formation is one of single peaks rather than chains of mountains, and few of these peaks reach up to the snow line.

This highest plateau may be distinctly recognized both north and south of the Wind River Mountains in latitude 44° and 45°, forming there a sage-plain desert at the sources of Jefferson's and Madison's Forks of the Missouri; and at the sources of Snake River, north of Fort Hall, a similar desert plain occurs, at least equally elevated. Passing some rough country south of these, another great plain extending from Laramie to Grand River is described by Fremont, Stansbury, and others. The valley of San Luis in northern New Mexico is another nearly desert area, notwithstanding its great altitude of nearly eight thousand feet. The Parks, though more fertile, belong to the same category of lofty plains, and southward along the Rio Grande the chain of these divides, and they pass at each side, retaining the same characteristics to Fort Webster and the Gila at the west, and nearly to the Rio Grande below El Paso on the east. Whatever doubt there may be in regard to assigning a place in the Rocky Mountain

system to the mountains of New Mexico west of the Rio Grande, either as a principal chain or as a bifurcation, there can be no doubt of this connection of plateaus. Both branches fall off in altitude to three or four thousand feet at the terminal points named, though that of the Sierra Madre on the west extends some distance toward the Colorado River, forming the Grand Cañon, in regard to which little is positively known beyond this general fact.*

At the highest point of this district only, or at the mountains in the vicinity of *Parks* described by Fremont in 39° north latitude, and at the Wind River Mountains in latitude 43°, the peculiarities better

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* Julius Froebel, in a sketch of the Physical Geography of the Continent in 1854, remarks particularly this plateau feature south of Las Vegas and the Raton Mountains, and he regards these last as the terminus of the Rocky Mountain chain in its greater features, as exhibited north of this point. "To the north he leaves steep, high, and mostly snow-covered mountains, while the elevations to the south are of two kinds, but both different in character from the great chain at the north. They are merely little isolated groups or ridges, such as the Placer, Sandilla, and Manzana Mountains. The rest are either mere declivities or detached portions of the general table land. The latter, at an average altitude of nearly 7,000 feet above the sea, turns round that same southern promontory, from the eastern to the southwestern side of the great chain, and, running out here in a projecting corner to the westward reaches the very borders of the valley of the Rio Grande, where, at many places, the traveller has a view over its edges down into the valley near Albuquerque. The little groups and ridges just mentioned have entirely the character of the numerous mountains *which, like the islands of an archipelago, are scattered over all the high plains of western Texas and Mexico.*" *Rep. of Smith. Inst.* 1854.

At the plain of San Luis, and over an immense area central a little southward of the South Pass, and reappearing north and west of the Wind River Mountains, the force of this description is as apparent as at the point referred to by Froebel. There are *Alpine exceptions*, with the plateau feature as the rule.

Mr. Froebel generalizes similarly in regard to the *western terminal range*, and cites a few Alpine exceptions south of the Old Spanish Trail. In the whole extent northward exceptions are equally rare.

Captain Beckwith's description of the great valley of San Luis is decisive of the point claimed here. He says: "The San Luis valley is from 40 to 70 miles in width, and still more in length, and so level that trees are seen in any direction growing on the streams, as far as the eye can discern them." "Elevation above the sea, 7,567 feet." He speaks of a "low, stony mountain range, which here extends across the broad valley of the Rio Grande, separating the valley of San Luis from that of Taos." As the ranges on either side are but an average of perhaps 11,000 feet above the sea, we have much the larger area and altitude, both made up in the lofty plateau. (See *Beckwith's Rep. of R. R. Survey*, 1855.)

A graphic remark of Fremont, in regard to the country near the South Pass, cannot be omitted here. "The region through which we were travelling was a high plateau, constituting the dividing ridge between the Atlantic and Pacific Oceans, and extending to a considerable distance southward, from the neighborhood of Table Rock, at the southern side of the South Pass. Though broken up into rugged hills of a dry and barren nature, it has nothing of a mountainous character, the small streams which occasionally occur belonging neither to the Platte nor the Colorado, but losing themselves in the sand or in small lakes."—(*Exped. of* 1843–4.)

described as "Alpine" are developed—the snow and ice remaining late, with the verdure and freshness belonging to high mountains in Europe in summer.* This character may belong, in part, to a central spot two and a half degrees of latitude by as many of longitude, but very much the greater portion of the Rocky Mountain district is one of plateaus in its surface character, and in its consequences in every respect—sandy, arid, treeless, and saline, in alternating tracts; interspersed, of course, with others essentially different, and with rich valleys. Thus the Valley of the Rio del Norte, which is the first in succession from the south, is in parts rich, and at others desert or basin-like; as the Bolson de Mapimi, and the basin of Lake Guzman, both on the south, and in Mexico; the Jornada del Muerto of the Rio Grande Valley in New Mexico, and the sand desert of the Pecos River; the sand hills and sandy plain of San Luis in the extreme north of New Mexico, at an altitude of 8,000 feet; the dry Laramie Plain at 5,000 feet; the high desert plain north of Fort Hall at 5 to 6,000 feet, and the Sage desert on the east of the central range of the Rocky Mountains at the sources of the Missouri, Jefferson's Fork, &c. All these points are no less characteristics of the surface and configuration of the Rocky Mountain district than the peaks and Alpine features of

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* Fremont's graphic description of this region can alone give an adequate idea of its features. (*Senate Report of Explorations in* 1842–43 *and* '44, p. 282, &c.) "The valley narrowed as we ascended, and presently degenerated into a gorge, through which the river passed as through a gate. We entered and found ourselves in the New Park—a beautiful circular valley of thirty miles diameter, walled in all round with snowy mountains, (June 14, 1844) rich with water and with grass, and fringed with pine on the mountain sides below the snow line. . . . Latitude 40° 52′ 44″; elevation by the boiling point 7,720 feet. It is from this elevated cove, and from the gorges of the surrounding mountains and some lakes within their bosoms, that the Great Platte River collects its first waters. . . . June 17; we fell into a broad and excellent trail made by buffalo, where a wagon would pass with ease, and, in the course of the morning, crossed the summit of the Rocky Mountains through a pass which was one of the most beautiful we had ever seen. The trail led among aspens, through open ground richly covered with grass, and carried us over an elevation of about 9,000 feet above the level of the sea. . . . The Old Park is more or less broken into hills, and surrounded by the high mountains timbered on the lower parts with quaking asp and pines." On the 20th June, he says: "A piney ridge of mountains with bare rocky peaks was on our right all day, and a snowy mountain appeared ahead;" in the afternoon, "proceeded up a flat valley bottom between timbered ridges on the left and snowy mountains on the right, terminating in large buttes of naked rock." At the camp: "By the temperature of boiling-water, our elevation was here 10,430 feet; and still the pine forest continued and our grass was good." On the 21st: "In a ride of about three-quarters of an hour, and having ascended, perhaps, 800 feet, we reached the summit of the *dividing ridge*, which would thus have an estimated height of 11,200 feet. Immediately below us was a green valley, through which ran a stream, and a short distance opposite rose snowy mountains whose summits were formed into peaks of naked rock." This was at the *South Park*, and on the sources of Arkansas River.

the district of the Parks and of the Wind River Mountains themselves.

West of this district lies a great homogeneous area of basins, merging at the south into the basins of Mexico enumerated above. Though drained by three large rivers, or traversed by them, rather, since they get most of their waters beyond it and very little in it—the Columbia, Colorado, and Gila—it is essentially an undrained region, or one sending no water to the sea. Nearly all its surface is studded with minor basins, the principal one of which is Great Salt Lake. Next is that of Humboldt River, and north and south of these an immense area possesses characteristics of great uniformity; the chief of which are an arid climate and barren surface. Sandy and saline tracts; salt lakes and marshes; mèsas, or high and abrupt plateaus of small extent, without wood, and deficient in all forms of vegetation; unaltered volcanic districts, and rough abrupt mountains make up most of the American Basin region.* The central portion in latitude is near the 40th parallel, and at an average of 4,500 feet above the sea, the northern extremity declines at the 48th parallel to 7 or 800 feet in the lower part of the great plains of the Columbia River, which form a climatological basin. At the south, the altitude falls off to sea level without changing its climatological character as a basin, and this decrease of altitude passes through several minor basins; in fact, that of the Mojahve River being one of the principal now known, and not much above the level of the Colorado River, while still another tract, west of the Colorado and further south, is at or below sea level.

The area occupied by this basin region is much greater than that of the great mountain plateaus, and if the bordering mountains on the west are included, embracing all the country at once elevated and arid, west of the greater altitudes before described, the area can scarcely be less than five hundred thousand square miles, of which the average altitude is 3500 to 4000 feet. The sum of this and the first district—seven hundred and fifty thousand square miles—expresses very forcibly the immensity of this feature of configuration; and it is more essential to bear it in mind in the consideration of climates than all that relates to single mountain ranges. And climates with great

* Froebel considers the Rio Grande Valley and the Mexican basins as part of the general basin system, and such they clearly are, though the number of actual basins is small, and all these are of limited area. This district passes into the characteristics of the dry country, east of the Rocky Mountains, by an equally gradual transition, and it is practically unimportant to which it is assigned. It would be better, as Mr. Froebel intimates, to regard the basins south of the Gila as belonging to a class of plateaus and minor basins properly Mexican, and differing in several points from those north of this line. In Climatology this distinction is easily marked and quite necessary.

extremes of temperature, and with the most complete interruption of symmetry in their changes, and the predominance of the local character in every respect, necessarily follow from this configuration.

So far as known, there is little difference either in configuration or climatological results, between this district and Central Asia. From the head of the Red Sea, the basins stretch at intervals northeastward, the Caspian and Aral Seas forming a part, and the great interior of Chinese Tartary, a part still greater, of a region in many respects homogeneous throughout. The Asiatic system or area, is much greater than the American, but it does not differ largely in latitude, nor are its peculiarities of surface or altitude wholly unlike that of North America. The valleys of most parts of the Mongolian Basin, are as high as those near the Great Salt Lake, though the Caspian and Aral Seas are very low, and in this respect in great contrast with the position of the small lakes here.

Williams, whose description of the basin region of China, is quoted at length in another place, defines the area of that part of Asia, at 1,200,000 square miles, extending in an oblique direction, or from southwest to northeast, from long. 72° to 120° east, and from 32° to 50° north latitude. This best and most recent description of that interesting portion of the Asiatic continent is still wanting in many of the details, by which its entire configuration and capacity may be understood, yet it is surprising that so great an area having no external drainage to the sea, should be so little known, and should enter so little into the consideration of general climate, and of the distribution of heat and moisture.

The Pacific coast with its mountains is the most difficult to describe, as its contrasts are so great in every respect. Its mountains shut off the basins of the interior as effectively as if a great distance and many ranges intervened, though the space they occupy is very narrow. From the interior westward, a quite uniform and continuous range is met with, the Sierra Nevada of California, and the Cascade Mountains of Oregon. As said before, north of 50° of latitude all these are merged in the Rocky Mountains as there defined, and this range is then equally near the Pacific, and equally shuts off the interior from the oceanic influence. This whole range is sharp, with snowy, humid summits, clothed with forests for the most part, and very rarely taking on the plateau form. This it does to some extent in the south of Oregon, and the north of California only. But at the southern extremity of the Sierra Nevada, lat. 34½°, the range declines so much that to its termination at the point of the peninsula of Lower California its influence on climate and its absolute configuration deserve but a small share of attention. These lower points are also less humid, and often destitute of forests

below 37° of latitude. The mountains corresponding in position in Europe and Africa extend from the Atlas Mountains to those of Spain, the Alps, and the coast mountains of Norway—all their representatives here being compressed within the distance from San Diego to Puget's Sound. Between these and the coast the valleys are mostly narrow, the plains small, and the declivities abrupt. The interior valley of California, bounded on the west by a bifurcation of the Sierra Nevada starting out at Tejon on the south, interrupted at San Francisco Bay, and joining the same chain again, in the south of Oregon, is the greatest of the Pacific plains or lowlands. It is very low and level, but too near the sea to partake of the characteristics of a basin region, except in its modified extremes of climate. In Oregon the Willamette Valley is a smaller tract partially so shut in by a range of coast mountains, and further north the greater portion of the country near Puget's Sound is so separated from the sea. But in the last case little modification of climate results, as its high latitude and the limited protection which exists prevent any decided effects.

The mountains nearest the Pacific coast are always secondary to the Cascade and Nevada range, though the last are often higher than the Rocky Mountains. They retain the abrupt and precipitous peculiarities belonging pre-eminently to the western mountains of North America, and have a much less proportion of wood and of cultivable slopes, than is usual to mountains of these latitudes. They seem newer than most other mountain systems, and to possess a less complete development of their capacities in vegetable production.

In review of the mountain configuration of the western coast and its vicinity some more general climatological results may be indicated.

Commencing at the south, the single range formed by the union of the coast range of California with the Sierra Nevada shuts off the sea climate completely, and changes the moderately humid air of the Pacific, as it must be at least, to that of one of the most fiery deserts known. Further north there are two ranges, separated by the valley of the Sacramento and San Joaquin Rivers in California, which is partially but not entirely dry. The lofty range of the Sierra Nevada completes the transformation. In Oregon also, the two stages are quite easily recognized—the partial change from the climate of the coast which is found in the Willamette Valley, the first after passing the coast mountains, and the complete aridity of the Snake River district, and the plains of the Columbia.

Along the whole coast the causes and effects are similar, and the mountain ranges are much sharper and more elevated above the general level than those rising from the interior plateaus. Some parts of the coast ranges are higher than any in the interior, the peaks of Mt.

Hood, Mt. St. Helens, and Shasta, are higher than the lofty Fremont's Peak of the Wind River Mountains, and higher also than Pike's and Long's Peaks, which rise from the loftiest point of the great plateau.

The extreme elevation of the coast ranges of mountains on the Pacific side of the continent, is one of the most marked points in the physical geography of the continent, and it undoubtedly has a very great influence over the climate of so much of the area as corresponds in position to Europe on the eastern continent. All the mountains near the Pacific coast, are remarkable for their great altitude, and the two ranges which are found in California and Oregon, almost equally intrude themselves, and equally change the climate. Between the coast and the first range, the humid atmosphere and warm winter of western Europe prevail, while east of that the change is such as to render it nearly a continental climate, with an atmosphere generally dry, and with variations of temperature similar to those of the eastern United States. Passing the second range, the Cascade Mountains of Oregon, and the Sierra Nevada of California, the change becomes quite extreme from the climate of the coast, and the country has very few cultivable districts.

Beyond the limits of the United States there are some points of configuration and some features of the surface character which may influence the general climate. The northern areas are very low on the whole, and the great interior of British America is scarcely above the average altitude of the Mississippi Valley. From Fort Laramie, indeed, a direct line northward declines two thousand five hundred feet before passing the northern limit of the United States—continuing to fall off rapidly toward the interior of the great northern plain. The greater portion of the continent north of the United States is a low plain, indeed, so little elevated as to soften the climate rather than otherwise, or to do so as much as land areas may in any case soften it. The northern portions of the Pacific coast ranges, and of the Rocky Mountains, soon get west of the coast meridians of Oregon, and they fall off greatly in altitude generally also, though some single high peaks remain.

The northern areas of Europe and Asia decline northward in the same manner, and they are of nearly the same altitude, except on some part of the Asiatic steppes. With this similarity of configuration, the differences of which fall in favor of America, and would imply a milder climate here, the more habitable character of the north of Asia can hardly be explained.

It is not clear what the influence of the mountains on the west of British America is upon its interior climate. It is certainly far less than that of the same ranges in the middle latitudes, and there are no

deserts resulting in any position. There seems to be no regular movement of wind castward at these high latitudes; none such is noticed by the authors of meteorological observations at the posts of the Hudson's Bay Company, and Richardson remarks a prevalence of northerly and easterly winds at the most exposed positions. The change of temperature and humidity during southwesterly winds is noticed as very great in Richardson's observations, and if these were the prevalent winds, his observations show that the climate would be greatly softened.

At the south the great altitude of the mass of Mexico has evidently something to do with the general climate of the lower latitudes of the United States, though it is not easy to say what that influence is. The coasts of the Gulf of Mexico on the north are peculiar, and exhibit some evidence of a basin-like collection of the atmospheric circulation —an eddy caused by wall-like impediments on the west. As the trade winds are not noticed in this interior, in the latitudes where they exist at sea, so much accumulation as they may cause is quite certain to occur, and the altitude of the land mass is sufficient to obstruct this movement by merely blocking the way. It is quite probable that the peculiarities of the climate of Texas and the vicinity of the Lower Mississippi are to some extent derived from this cause.

The configuration of the portion of the continent south of our own territory cannot, it is clear, be thrown out of the account in making up the general results in the climatology of the southern districts. The great altitude of the Rocky Mountain plateau is again attained very soon after passing the depression at the source of the Gila. It is at this latitude, near 32°, but little more than five thousand feet above the sea; but at the south, it again rises at least two thousand five hundred feet higher, and at the north, the difference is twice as great where the highest point is attained. The depression at the Gila does not interrupt the continuity of this mountain mass, so much as to modify the climate materially, and the arid character here is but a degree less than where the sharp mountains of California and the highest ridges of the Rocky Mountains join to influence the climate.

There are some other points of interest in this connection, which may be given in conclusion, with a table of the determined altitudes of a sufficient number of points to define the vertical configuration with sufficient accuracy for the present purpose.

These points of peculiar character are the *cañons*, or gorges of singularly abrupt character which belong to the river-beds of most of the region west of the Rocky Mountains; the *mèsas*, or small elevated plateaus, as abrupt at their banks as the declivities of the first, yet rising from the general level instead of sinking below it; and last, the

saline and alkaline basins, or mud beds. The limit of volcanic tracts, or those covered with recent debris of eruptions, lava ashes, pumice, &c., may also be of sufficient importance to repay designation.

The term "cañon" (*kanyon*) has been introduced by the Spanish to designate the passage of streams—the place of passage—between perpendicular rocks of great height, which sometimes form a tunnel, indeed, closing more nearly at top than at the level of the stream. The whole plateau region is characterized by these cañons, and particularly the upper portions and tributaries of the Rio Grande, the Grand and Green Rivers of the Colorado, Snake River, and the Platte. It is possible to represent the local topography near these only by a notation similar to that indicating a range of mountains on the very borders of the streams. These stupendous cliffs belong to the Rio Grande for a great distance above Santa Fe, though below that point they recede from the river, leaving a wide valley, to Valverde; near which point a chain of mountains again lies along the river, and the road is turned away to cross the Jornada del Muerto. Below El Paso the cañons again occur, and they are of the most formidable character until the low country of Texas is reached.

The Colorado of California and its great branches, the Grand and Green Rivers, traverse these gorges through their whole course to within three hundred miles of the sea. A portion of this distance below the junction of Grand and Green Rivers is so nearly impassable because of these gorges, that the explorers who have traversed almost every other district, have been repelled hitherto, leaving much of it unknown.*

* Fremont alludes to one or two of the tributary cañons as follows: "Our camp was in a basin below a deep cañon—a gap of two thousand feet deep in the mountain—through which the Rio Virgen passes, and where no man or beast could follow it." This is a tributary of the Colorado from the west. Again, at a point southeastward of Great Salt Lake: "Here, at this point, by observation 7,300 feet above the sea, we had a view of the Colorado below, shut up among rugged mountains." . . Near *Brown's Hole* "the river enters between lofty precipices of red rock, and the country below is said to assume a very rugged character, the river and its affluents passing through cañons which forbid all access to the water." . . . "From the lower end of Brown's Hole we issued by a remarkably dry cañon, fifty or sixty yards wide, and rising as we advanced to the height of six or eight hundred feet. Issuing from this and crossing a small green valley, we entered another rent of the same nature still narrower than the first, the rocks on either side rising in nearly vertical precipices perhaps 1500 feet in height." (*Expedition of* 1843–44.)

Sitgreaves (*Report of Exploration of Zuni and Colorado Rivers*, 1851) describes the gorges and cañons of the Colorado as very formidable at the 35th parallel, and in several cases below this point, and gives figures of some of them. The *Grand Cañon of the Colorado* as known to trappers and hunters, though not yet visited by scientific engineers, is placed by Sitgreaves in lat. 36°.

The gorges of the rivers of California in the Sierra Nevada are probably such only as belong to all abrupt mountain regions, and, though they are often of extraordinary depth, and eminently *cañons*, they are not new features of topography, as in the plateau districts. Snake River, or Lewis's Fork of the Columbia, is next to the rivers before named in this character. Fremont's account of this, near Fort Hall, says:—

"Between the river and the distant Salmon River range the plain is represented by Mr. Fitzpatrick as so entirely broken up and rent into chasms as to be impracticable for a man even on foot." And at a point in lat. 44° 20′ he says: "The Snake River is said henceforth to pursue its way through cañons, amidst rocky and impracticable mountains, where there is no possibility of travelling with animals." (*Expedit. of* 1843–44.)

The upper portions of this river exhibit some deep gorges, though they are less remarkable than those in its course from lat. 44° 20′ to Walla Walla, and on the eastern tributaries for this distance.*

The Des Chutes plain between the Cascade Mountains and the Blue Mountains of Oregon is also traversed by cañons of immense depth, cut through the volcanic and sedimentary strata by streams. Most of these desert plains are peculiarly favorable localities for the action of streams in excavation of their beds, and the whole of the basin region, with its borders, is so excavated when the drainage opens to any river of lower level, or to the sea.†

The Platte River with its tributaries is also conspicuous for these cañons. Fremont reached the first on the Sweet Water at long. 108° 30′, and this he describes as often no wider than the stream, or twenty to sixty yards, and as bounded on both sides by granite rocks rising precipitously to the height of 300 to 500 feet. He subsequently descended the North Fork of the Platte through two or three gorges in ridges of granite where the walls were 500 feet high, and the rapids impassable in safety. There are few of these, however, that are formed by its passage through beds, plateaus, or *mèsas* of sedimentary rocks, as is so generally the case on the Colorado. The gorges appear to be most frequently and naturally formed by the rents and chasms of an immense stratified geological formation, uplifted sometimes horizontally,

* Dr. Macfeely, of the N. Pacific R. R. Survey, says of this river near its northerly bend, "we came suddenly in sight of Snake River running through a deep chasm a thousand or fifteen hundred feet below us," and he speaks of it as continuing through deep and almost impassable cañons to Fort Walla Walla.

† Prof. Newberry in a paper read before the American Association at Albany, 1856, describes these cañons as often 2000 feet in depth in the Des Chutes plain, which is drained northward to Columbia River. The cañons of Klamath plain, which is drained into the Sacramento in California, are scarcely less formidable.

and usually at very moderate grades of declivity, by the forces which elevated the whole plateau region.

The mèsas, and their relation to the characteristic features of the topography distinguished here, are so well described by Captain Beckwith,* at his passage of the Grand River, a branch of the Colorado of California, as to make the point of the present reference clear.

"On each side of the river to-day, and as we can see, for some days ahead, the banks rise rapidly towards the precipitous sides of the mèsas, which extend back from fifteen to thirty miles to the mountains. These elevated tables are in classes, each class preserving the same level, though on opposite sides of the river, and consisting of the same formations—all of them terminated at the top by a capping of greater or less thickness of igneous rocks, overlaid by a few feet of soil, on which, occasionally, small groves of trees may be seen. They were formed, doubtless, by the upheaval of large plains at the same time, and the immense cracks and crevices of those convulsions have been enlarged, in time, by the elements, and now form the cañons, gorges, ravines, and passes which everywhere surround us. While the current of the river is rapid, and the descent very considerable, these tables seem to preserve the same absolute level, and consequently become more elevated above the river as it descends. They are judged to be to-day 1200 feet above it, and not less than 1500 feet at 20 miles west of us."

In addition to this it need only be said, in brief, that these mèsas, or high plains, belong mainly to the southern parts of the plateau region, from Western Texas to California. They are not unlike the *coteaus* of the Missouri, and with the great altitude they have west of the Rocky Mountains and near the Colorado, together with the immense area some of them have, as the Llano Estacado of Western Texas, they cannot be passed over in defining the topography which controls climate.

The saline and alkaline lakes, basins, &c., occur over the whole basin and plateau region, and they belong more or less to all the districts which are dry in summer, and without a great precipitation in winter. Fremont found them on the Laramie plain near the South Pass; they exist near Fort Hall, on the high plain at the sources of Snake River of the Columbia; on Jefferson's fork of the Missouri at a high plain belonging to the Rocky Mountain plateaus; and also at various points in the plains of the Columbia. Captain Beckwith found sinking streams and saline efflorescence at the head of the San Luis Valley of New Mexico, in the immediate vicinity of the most extremely Alpine regions of the continent. They are a prominent feature of every part of the basin region proper as a matter of course, and need not there

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* Report of Pacific R. R. Survey, 38th and 39th parallels, 1854. Mr. Marcou, Geologist of the Survey of the 35th parallel, designates the Llano Estacado of Texas as a formation common to all the *mèsas* east of the Rio Grande, and, in two steppes, covering most of the district in the form of high table lands.—(*Captain Whipple's Report.*)

be described, except to say in what degree they exist. All these have undoubtedly a climatological significance, and they are decisive of a high degree of summer heat, with an arid atmosphere and little rain or snow.

In this view some more definite notice is required of the saline localities near the line of their commencement from the East. At the northwest of the sources of the Mississippi there is a large "salt-water region," composed of lakes and ponds, generally only slightly saline, and evidently so because of great evaporation and defect of drainage. It lies on the high plateau between Red River and the Missouri, and is freely drained only at rare instances of floods. The quantity of rain here is greatest in summer, but this season is also relatively warm and favorable to evaporation, and in winter the quantity of water falling in rain and snow is very small. Along the dividing plateau at the north of the Missouri to Fort Union, saline marshes and lakes are reported as occurring irregularly,* and the peculiarly rapid evaporation which causes these saline features is particularly referred to. Saline waters are also found to some extent over the arid uplands of the Mauvais Terrès, between the Missouri and Platte. South of the Platte, Fremont observed saline efflorescences at the 100th meridian,† and frequently afterward and westward on the higher plains. Near the Arkansas River, and particularly on the south of it, these saline tracts are much more abundant, and they reach to the 98th meridian, eastward; occupying, as it is said, a large area here, of which little is positively known.

On Red River, Captain Marcy found "the inhospitable and dreaded salt desert" to commence at the 101st meridian, and westward of that point most of the tributaries of the river are highly saline and alkaline. The plateaus and ridges between the great rivers are doubtless interspersed with salt plains, to some extent, though Captain Marcy regards the phrase above quoted, and the statements frequently made in regard to that district, as greatly exaggerating its desert character. Southward of Red River all the streams rising in Upper Texas are more or less saline, or have "Salt Forks," indicating the presence of saline and alkaline tracts, at least to the degree belonging to its climatological character.

In brief, all the more elevated portions of the great plains of the eastern slope of the Rocky Mountains develop districts of sufficient aridity to be necessarily associated with, and doubtless to cause salt

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* Lambert's Topographical Report, N. Pacific R. R. Survey.

† Expedition of 1842: "In the vicinity of these places there was a bluish grass which the cattle refused to eat, and which the voyageurs call 'herbe salée,' salt grass.

plains, and to give this saline character to many of the minor streams. These districts have a definite relation to the altitude also, or they occur only at certain altitudes on these plains, and they are a noticeable feature of the climatological topography.

The salt lakes of the Great Basin are among the most concentrated saline waters known, and at low water many of them are in great part solidified. Masses and plains of solid salt are often found there, and they show the greatest degree of aridity of climate associated with an entire absence of exterior or sea drainage. The central areas and table lands of Asia are similar. Russia in Asia, and Russia in Europe have many districts with salt plains, and lakes of saline water, salt mud and marshes. In addition to the internal seas so well known, Murray says that "chains of saline lakes of considerable magnitude extend through the interior table land of Asia Minor." The conditions in like latitudes of the two continents are strikingly similar in this respect, differing only in degree corresponding to the immensely greater area of the Asiatic steppes, and of the plains of its vast interior less elevated than the steppes proper.

A remark may be made here in regard to a feature of vertical configuration which has so far been entirely passed over, the Black Hills, which have been supposed to constitute a mountain chain diverging from the Rocky Mountains near Fort Laramie, and extending northeastward nearly to the Missouri River, at the point of its extreme northeastern bend. Reference to these is omitted because it is now certain that they have no rank as a chain of mountains, and it is believed that they constitute merely a high plateau, differing in no great degree from the Coteau du Missouri east of that river, or from other high plains which separate the drainage of districts in an equal degree. There can be no mountains there of climatological importance beyond their immediate district in any event, such, possibly, as the scattered mountains on the Upper Missouri, and the Wichita Mountains, between the Canadian and Red Rivers, on the southern part of this great plain.

VERTICAL TOPOGRAPHY, TABLE OF ALTITUDES.

To illustrate the vertical configuration of the United States, and the portion of British America necessarily included, classified lists of positions representing the several districts may be given, commencing at the northeast. The best expression of the relation of these altitudes to the climate may, perhaps, be attained by arranging the points in lines at right angles to the trend of the Alleghany ranges, which will be nearly northwest and southeast. All the elevated ridges and dis-

tricts east of the Mississippi belong to this class, the class designated generally the Appalachian range, though west of the St. Lawrence the hills and ridges are less regular. The several lines are numbered from the northeast, and the positions are arranged from the Atlantic coast inland.

Locality.	Altitude. Feet.	Authority.	Remarks.
1. Transverse Section.			
Fredericton, New Brunswick	50	—	Tide-water. Low country of New Brunswick.
Houlton, Maine . . .	620	Graham, U. S. T. E.	General level inland.
Mars Hill	1506	Graham.	Isolated and highest peak.
Fort Fairfield	415	Graham.	Valley of St. John's River.
Fort Kent	575	Graham.	Valley of Aroostook River.
Dividing range in lat. of Quebec	1500	*Est.*	From various descriptions.
Cape Diamond, Quebec . .	230	—	Table land near Quebec.
Ridges beyond St. Lawrence .	1000	Richardson.	Estimate for Highlands toward Hudson's Bay.
2. Transverse Section.			
Bangor, Maine . . .	250	—	Vicinity of city at tide-water.
Central Hills	1200	*Est.*	Hills near the lakes of interior.
Moosehead Lake . . .	1000	?	Interior valleys.
Mountain range at west boundary of Maine . . .	3500	Hunt.	In latitude of Montreal.
Connecticut Lake, N. H. . .	1589	Thompson.	Source of Connecticut River.
Lake St. Peters . . .	0	—	Tide-water. St. Lawrence valley.
Hills beyond St. Lawrence .	800	Richardson.	Highlands of plateau, estimated.
Lake Temiscaming . . .	612	Logan.	Source of Ottawa River.
3. Transverse Section.			
Dover, N. H.	250	—	Tide-water. General level.
Blue Hills, N. H. . . .	1150	?	First inland range.
Winnipiseogee Lake . .	472	?	Interior valleys of N. H.
Mount Washington . . .	6285	Guyot.	Barometric observation.
White Mountains . . .	5836	?	Average of 8 highest peaks.
St. Johnsbury, Vermont . .	585	Thompson.	Upper valley of Conn. River.
Green Mountains, Vt. . .	4000	Thompson.	Average of 8 highest peaks; S. Vermont.
Craftsbury, Vt. . . .	1158	Thompson.	Highlands of N. Vermont.
Montpelier, Vt. . . .	540	Thompson.	Central Valleys.
Lake Champlain . . .	90	Thompson.	—
Montreal	70	McCord.	Tide-water.
Hills beyond St. Lawrence .	800	Richardson.	Including the marshy plateau in which the rivers rise.*

* "With respect to the general character of the ridge which divides the St. Lawrence Valley from that of Winnipeg Lake the aspect of the country traversed in pursuing the canoe route may be considered a type of the whole. The surface of that tract is hilly, the granite rising in rounded and sometimes in rugged knolls abruptly from lakes and swamps, but only to small heights above the general level. . . The term *ridge* is used with reference to its being a height separating two depressions; but

Locality.	Altitude. Feet.	Authority.	Remarks.
4. TRANSVERSE SECTION.			
"N. W. corner of Rhode Island"	633	Borden.	Most elevated portion of R. I.
Worcester, Mass.	536	Borden.	Average of Eastern Mass.
Eastern Hills	1000	f'm Borden.	Average for the highest range east of Conn. River.
Brattleboro' Vt.	160	Thompson.	Conn. River Valley.
Berkshire Hills, Mass. . .	1500	—	Average of range.
Pass of Berkshire Hills . .	1440	R. R. Sur'ys.	Lowest pass to Hudson River.
Williamstown, Mass. . .	800	Dewey.	Western declivity of hills.
Albany	150	—	Tide-water.
Schenectady, N. Y.	227	Canal Sur.	Lower valleys of Eastern N. Y.
Johnstown, N. Y.	688	*Reg. Rep.*	Central valleys.
Highlands of Northern N. Y. .	1658	Benedict.	Average of 12 principal lakes, 1500 to 1850 ft. each.
Mt. Marcy	5344	Benedict.	Highest point in State of N. Y.
Lion Mountain range . .	3800	Johnson, C.E.	R. R. Surveys in Northern N. Y.
Hills at Province line . .	1085	Johnson.	
Table land west of mountains .	1500	Johnson.	
Potsdam, N. Y.	394	*Reg. Rep.*	Low plain of Northern Counties.
Ogdensburg, N. Y.	229	Johnson.	St. Lawrence Valley.
5. TRANSVERSE SECTION.			
North Salem, Westch. Co., N. Y.	170	Coffin.	Plains of Westchester Co.
Highlands of the Hudson .	1200	Emmons.	Ranging from 700 to 1680 ft.
Newburgh	150	*Reg. Rep.*	Tide-water, valley of Hudson.
Catskill M'ts	3000	Guyot.	Average of the range.
Catskill M'ts	3800	*Geol. Sur.*	Highest points.
Otsego Lake	1193	Vanuxem.	Interior valleys.
Utica	473	*Canal.*	Lowest interior.
Bridgewater	1286	*Reg. Rep.*	Plateau near Utica.
6. TRANSVERSE SECTION.			
Palisades, near New York .	500	Mather.	The first elevations.
Schooley's Mountain, N. Jersey	1100	*Lip. Gaz.*	Second ridges in New Jersey.
Shawangunk M'ts, N. Y. . .	2800	*Geol. Sur.*	Principal m'ts of South. N. Y.
Delhi, N. Y.	1384	*Reg. Rep.*	Upper valleys of Delaware R.
Oxford, N. Y.	961	(Do.)	Do. Susquehanna R.
Tully Lakes, N. Y.	1194	(Do.)	High plateau near Susq. River.
Ithaca, N. Y.	417	(Do.)	Lowest valleys of int. lakes.
Canandaigua	813	Hall.	Canandaigua Lake, 668 feet.
Rochester	516	Dewey.	Represents an extended plain.
Lake Ontario	232	Hall.	Much of the south shore is but little elevated above the lake.
Toronto, Canada	341	Lefroy.	Average of a large part of Canada West.
Lake Simcoe	704	Murray.	
Hills north of Lake Huron .	1100	Logan.	Cana. Geol. Survey.

its summit is a marshy plateau of some extent, across which narrow winding lakes afford a canoe navigation in a variety of directions."—*Sir J. Richardson's Arctic Expedition in Search of Sir J. Franklin.*

Locality.	Altitude. Feet.	Authority.	Remarks.
Hills north of Lake Superior	1500	Richardson.	Av. of ridge near the lake.
Thousand Lakes	1458	Richardson.	Plateau west of the ridge.
Lake Winnipeg	853	Richardson.	Plain descending to Hudson's Bay.
7. Transverse Section.			
Summit of Union Canal, Reading, Pa.	450	Shaeffer.	Average of county east of Blue Ridge.
Blue Ridge of Pa.	1100	—	General average.
Pottsville, Pa.	640	?	Interior valleys of Eastern Pa.
Williamsport, Pa.	500	Shaeffer.	Average of Susq. River valley.
Sinnemahoning Summit, Pa.	1900	Miller.	High plateau at sources of Alleghany River.
Coudersport	1649	Miller.	
Chautauque Lake, New York	1306	Ellet.	
Highlands of Chaut. Co., N. Y.	1550	Ellet, &c.	Represents a large district of Western N. Y. and Penn.
Fredonia, N. Y.	710	*Reg. Rep.*	A large belt of the south shore of Lake Erie.
Lake Erie	565	*Canal levels.*	
Barry, Central Michigan	914	Higgins.	Central dividing ridge.
Mackinac	728	*Met. Reg.*	Isolated Island ; Lake 600 feet.
Hills south of Lake Superior	1550	Owen.	Average of measured points.
Penokie Mountains	1840	Owen.	Average of highest points south of Lake Superior.
Sources of Mississippi River	1680	Nicollet.	Highest point of plateau.
Pembina, Red River	850	Long.	Lowest interior valley.
8. Transverse Section.			
Parr's Ridge, n'r Frederick, Md.	639	*R. R. Sur.*	Average of Central Maryland.
Blue Ridge of Md. and Va.	1800	*Est.*	Near Harper's Ferry.
Valley of Virginia	800	*Est.*	Valleys near the Potomac.
Altona, near Cumberland, Md.	2620	*R. R. Sur.*	Summit of Balt. and Ohio R. R.
Pass of Alleghanies	2400	Ellet.	Lowest pass at sources of Cheat and Greenbrier Rivers.
Cheat River, Virginia	1375	Ellet.	Valleys of the western declivity.
Tygart's Valley, Va.	1000	Ellet.	Lowest of these, within the mts.
Pittsburg	700	Ellet.	Low water of Ohio.
Plain near Pittsburg	1100	Drake.	Upper plain near the city.
Summit between Ohio and Lake Erie	990	Ellet.	Sources of Muskingum and Cuyahoga.
Hudson, Ohio	1131	Loomis.	Highlands near Lake Erie.
Lake Erie	565		
Hillsdale Co. Michigan	1211	*R. R. Sur.*	Highest point in the lower peninsula of the State.
9. Transverse Section.			
Alluvial Plain of Va.	60	—	
Charlottesville, Va.	120	Williams.	Low plain near Rockfish gap, 100 ft.
Rockfish Gap of Blue Ridge	1247	Turner.	"From Surveys."
Blue Ridge of Central Virginia	4000	Turner.	Average of highest peaks.

Locality.	Altitude. Feet.	Authority.	Remarks.
Staunton, Va.	1152	Turner.	These represent the "Valley of Virginia" at this latitude, averaging 1000 feet.
Pattonsburg, Va.	902	Turner.	
Covington, Va.	1222	Turner.	
Alleghanies at lat. $37\frac{1}{2}°$	2650	Turner.	Average of four peaks.
White Sulphur Springs	2000	Williams.	West. plateau at lowest points.
Alleghanies near Red Springs	2760	Williams.	
Charleston, Kanawha River	600	Ellet.	Low valley of Kanawha River.
Portsmouth, Ohio	540	Drake.	Site of town.
Hillsboro', Ohio	1131	Matthews.	Highlands of Southern Ohio.
Columbus, Ohio	762	Drake.	Central Ohio on the west of the hilly district.
Bellefontaine Summit, Ohio	1400	Christy.	"Highest land in Ohio."
Northern Indiana	850	Drake.	Sources of Maumee.
Northern Indiana	745	Ellet.	Sources of Wabash and Maumee.
Chicago	590	Houghton.	From alt. of Lake Michigan.
Beloit, Wisconsin	750	Lathrop.	Valley of Rock River and others of N. Illinois.
Prairies of Ills. and Wisconsin	950	*Est.*	General height of large prairies.
Blue Mounds of Wisconsin	1640	Geol. Surv.	Hill summits of Southern Wisc.
Prairie du Chien	642	Nicollet.	Valley of Mississippi River.
10. TRANSVERSE SECTION.			
Alluvial Plain	60	—	Tide-water plain of N. C. & S. C.
Eastern foot of Blue Ridge	1200	Guyot.	In North Carolina.
Blue Ridge	3200	Mitchell.	Average in North Carolina.
Black Mountains of N. C.	6509	Guyot.	Ave. of highest 8 points (1856). *Black Dome* 6760; *Deer Mt.* 6213.
Asheville, N. Carolina	2000	Guyot.	Lowest mountain valleys.
"Seven Miles Ford," Holst. R., Va.	1914	Crozet.	Do. in S. W. Virginia.
Alleghanies at 36th parallel	5000	Guyot.	Average for 150 miles between Tenn. and N. C.
Alleghany Plateau at 37th parallel	2563	Crozet.	Sources of New River and Tenn. River at Mt. Airy.
Cumberland Mountains, Tenn.	2500	Guyot, &c.	Average of range or plateau.
Central Kentucky	800	—	Derived from surveys, &c.
Louisville, Ky.	441	Drake.	Site of city and valley of Ohio.
Mouth of Ohio	290	Drake,	Nicollet, by barometric observation; Child and Ellet, from Canal and Railroad Surveys from Lake Erie; Drake, a correction on these.
	275	Child, Ellet,	
	324	Ferrier, Nicollet.	
Mississippi River at St. Louis	381	Engelmann.	Low water.
St. Louis	480	Engelmann.	Upper portion of city.
11. TRANSVERSE SECTION.			
Alluvial Plain	60	—	South Carolina and Georgia.
Athens, Ga.	870	Prof. McCay.	Uplands of Georgia.
Blue Ridge	1800?	White.	Average of ridge.
Knoxville, Tenn.	960	Morris.	Valley of S. E. Tennessee.
Alleghanies of Alabama	1200	f'm Drake.	Terminus of range n'r Huntsville.
Huntsville, Ala.	600	Drake.	
Chattanooga, Tenn.	643	Thomson.	Valley of Tenn. River.

Locality.	Altitude. Feet.	Authority.	Remarks.
Nashville, Tenn. . . .	460	Hamilton.	
Cumberland River at Nashville	388	Thompson.	Low water.
Memphis	400	Drake.	Average of W. Tennessee.
Primary Hills, Madison Co., Mo.	1046	Nicollet.	Eastern part of Ozark Hills.
Ozark Hills	1500	?	Highest average in Mo. and Ark.
Hot Springs of Arkansas . .	718	Nicollet.	
Highest ridge near Arkansas .	1406	Nicollet.	Ridge south of Arkansas River.
Fort Gibson	560	Coolidge.	River valley west of Ozark Hills.

To express these results in a brief resume, we have, first, the coast or low lands, which do not form a wide belt in the New England States before rising into a country more or less hilly, and 250 to 800 feet above the sea. In this character they reach inland a considerable distance, and penetrate along the large rivers for a distance of three to five hundred miles—in fact joining the St. Lawrence and Mississippi plains over the whole region of the Lakes.* South of New York this coast plain is better defined, lying very low, and from eighty to two hundred and fifty miles wide. All this is practically at sea level as regards its climatology. Next is the Atlantic slope of the Alleghanies, which, as we have seen, is very irregular. In the south it is an abrupt rise to the Blue Ridge, which may be set down to average 2000 feet; or, more accurately, nearly 3000 feet in North Carolina to an average of 1500 feet from Maryland northward; and the first ranges of hills from the east in the New England States are nearly equivalent to such a ridge as an interruption of the atmospheric condition of the low country toward the sea. The interior valleys of the southern districts are next, and these average 800 to 1200 feet for those in the vicinity of the Blue Ridge. Near the Alleghanies they are higher, attaining from 1600 to 1900 feet in elevation there, though the mountains are no higher than the Blue Ridge.

The Alleghany ridges at 2500 feet are next, and these are quite uniform from Tennessee to Northern Pennsylvania. The western slope is last, and this is more abrupt than the eastern, falling off rapidly to the levels of the Ohio and Mississippi Rivers, at 400 to 600 feet above the sea only. This great interior plain is like the Atlantic plain, for climatological purposes practically at sea levels.

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* In Mather's Report on the Geology of New York this configuration is forcibly expressed by the statement that an influx of water rising 250 feet would join the Hudson River with that of Lake Champlain over the plain near Sandy Hill and Whitehall, N. Y.; and that a rise of 400 feet would connect the waters of the Mohawk valley with Lake Ontario over the low plateau west of Utica. To connect the Great Lakes with the Mississippi Valley over the plains south of Chicago but 610 feet rise would be necessary; and with this a vast area of the Eastern United States would be flooded, connecting all its systems of waters.

The slope of the western declivity of the Alleghanies has been examined with great care by Mr. Ellet,* an able engineer, and it may suffice for the present purpose to refer to some of the very gentle grades which he finds to belong to all the rivers tributary to the Mississippi. Taking the Alleghany River near its source in Northern Pennsylvania he gives the following grades to the Gulf of Mexico. The rivers tributary to the Ohio have almost precisely similar grades for streams of similar size on the south; or the Monongahela, Kanawha, Licking, Cumberland, and Tennessee Rivers are quite like the Alleghany in their grade of descent where the volume is the same. The tributaries of the Ohio on the north are less rapid near their sources, as they come from an interior of moderate elevation only, and without mountains.

Fall of the Alleghany River.

			Ft.	In.	
From	Coudersport, Pa.	to Olean, N. Y.	6	2	per mile.
"	Olean	" Warren, Pa.	4	4	"
"	Warren	" Franklin, Pa.	3	3	"
"	Franklin	" Pittsburg, Pa.	2	0	"
"	Pittsburg	" Beaver, Pa.	1	1.85	"
"	Beaver	" Wheeling, Va.	0	9.5	"
"	Wheeling	" Marietta, Ohio	0	6.53	"
"	Marietta	" Le Tart's Shoals	0	6.17	"
"	Le Tart's Shoals	" Mouth of Kanawha	0	7.2	"
"	Kanawha	" Portsmouth, Ohio	0	6.13	"
"	Portsmouth	" Cincinnati	0	4.8	"
"	Cincinnati	" Evansville, Ia.	0	4.1	"
"	Evansville	" Gulf of Mexico	0	2.813	"

In the item next the last, the falls of the Ohio at Louisville are also included, they amount only to 25¾ feet. Mr. Ellet shows that all the rivers of this interior plain have a grade of but a few inches to the mile generally, and that only at their sources do any of them show so rapid a descent as the first grade given for the Alleghany.

East of the Alleghanies the river grades are less regular, and the lower portions of all the largest are reached by the tide for great distances into the interior. From the Hudson northward the lower valleys appear to be basins of rupture, or of excavation by agencies more powerful than the flow of waters, and they form natural chasms in granitic formations. At the north and interior the lake basins appear to have been excavated by violent diluvial agencies, in a similar geological formation. Of the rivers of the Southern States many of them debouche in tide-water bays reaching some distance inland,

* Physical Geography of the Mississippi Valley, by Charles Ellet, Jr., C. E.

not inclosed by rocky hills, but shallow with the washings of the recent geological formations of the country. In the Mississippi plains they occupy mere water-paths, recently cut by their own volume in a uniform and still-water geological deposit.

ALTITUDES OF THE WESTERN PART OF THE CONTINENT.

The statistics of vertical configuration west of the Mississippi may be more expressive if arranged on the meridians, or on lines north and south through the entire temperate latitudes. The lowest portion of the interior, to which the Mississippi is central, is on a right line north from the Gulf of Mexico to the 45th parallel, at which point it is abruptly transferred from the 91st to the 97th meridian. Except at the Ozark hills there are no elevations of importance not already noticed, as some have been at the Upper Mississippi, before reaching the 100th meridian, at which some portions of the arid region begin. The arrangement of the points of these lines will be most convenient from the south.

Locality.	Altitude. *Feet.*	Authority.	Remarks.
100TH MERIDIAN.			
Laredo, Texas,	400	B'nd. surv.	Lower Rio Grande Valley.
Fort Duncan, Texas	800	Do.	Rio Grande.
Fort Inge, Texas	845	Graham.	Lower Texas.
Fort McKavett, Texas	2060	Crawford.	Uplands of S. Texas.
San Antonio, Texas	600	Graham.	Eastern foot of Uplands.
Fort Chadbourne, Texas	2160	Johnston.	Uplands.
Fort Belknap, Texas	1800?	From Pope.	Uplands near Pope's line.
Canadian River, Texas	2392*	Whipple.	General level of plain.
Fort Atkinson, Arkansas River	2331*	Beckwith.	Do. Long. 100° 14′.
Kansas River	2130	Fremont.	Plains, long. 100° 31′.
Fort Kearny, Platte River	2360	Fremont.	Do. long. 98° 57′.
Fort Pierre, Missouri River	1530*	Donelson.	Valley of Missouri River.
Fort Clarke, Mo. River	1827*	Donelson.	Do. long. 101°, lat. 47°.
Coteau du Missouri	2000	Stevens, est.	Western part of Coteau.
Near Shayenne River	1463	Stevens.	Prairie north of Coteau.
Lake Winnipeg	853	Richardson.	Level of Brit. Amer. Lake Dist.
105TH MERIDIAN.			
Bolson de Mapimi, Mexico	3785	Wislizenus.	Basin S. of Rio Grande.
Chihuahua, Mexico	4638	Wislizenus.	Long. 106° 30′.
Presidio Del Norte, Mexico	3000	*Est.*	Rio Grande Valley.
Ojo del Cuerbo, Texas	3893	Pope.	Salt Basin N. of Rio Grande.

* The altitudes so marked were determined by the writer for the several parties conducting these surveys, from barometric observations made under direction of the officer named as authority.

Locality.	Altitude. Feet.	Authority.	Remarks.
Guadalupe Pass, Texas . .	5716	Pope.	In Guadalupe M'ts E. of Basin.
Llano Estacado,† " . .	2995	Gray.	Southern Point, lat. 32°.
Do. " . .	2450	Marcy.	Sources of Red River; lon. 103°.
Do. " . .	4207*	Whipple.	North. extremity; lon. 102° 53′.
Anton Chico, New Mexico .	5414*	Whipple.	Near Estacado; lon. 105° 9′.
Las Vegas, " . .	6418	Emory.	Border of Plains; lon. 105° 16′.
Fort Union, Moro, " . .	6670	Emory.	Near Raton Mountains.
Bent's Fort, Arkansas River .	3958	Emory.	Long. 103° 1′, Emory.
Apishpa River, branch of Arkansas River . . .	4860*	Beckwith.	At foot of m'ts; highest point of the great plains, long. 105°.
Arkansas River . . .	4880	Fremont.	Mouth of Fontaine-qui-bouit; long. 104° 58′.
South Fork of Platte . .	4500	Fremont.	Fort St. Vrain; long. 105° 12′.
Fort Laramie	4470	Fremont.	Border of Plains; long. 104° 47′.
Plateau of Black Hills . .	5000	*Est.*	Highest point of *Coteau*, lat. 43°.
Fort Union of Missouri . .	2022*	Donelson.	Valley of Missouri; long. 104°.
Plain of Missouri . . .	2500	Stevens.	Approx. alt. of the Plateau at N. of Missouri; long. 105°.
Carlton House . . .	1100	Richardson.	Saskatchawan R.; long. 106° 13′.
Cumberland House . . .	900	Richardson.	Do. long. 102° 20′; lat. 53° 57′.
Churchill River . . .	700	*Est.*	Lat. 56°, and at 105th meridian.
110th Meridian.			
Lower Sonora, Mexico . .	Sea level.	—	On the Gulf of Cal., lat. 27°.
Rio San Pedro, Sonora . .	3500*	Parke.	Valley among ranges of mts. of 5000 ft. elevn. Lat. 31° 50′.
Gila River, N. Mexico . .	2852	Emory.	Represents most of the adjacent part of this valley, though lower than the tributaries of Gila from either side.
Copper Mines, N. M. . .	6200	Whipple.	Long. 108° 4′, sources of Gila R.
Little Colorado River, N. M. .	5012*	Whipple.	Upper part of river, lat. 34° 53′.
Fort Defiance, N. M. . .	7200	Whipple.	Represents much of W. N. M.
Zuñi, N. M.	6355*	Whipple.	Do. long. 108° 30′.
Grand River Plain, N. M. .	4642*	Beckwith.	High plain between Grand and Green Rivers, lat. 39°.
Grand River, " . .	4410*	Beckwith.	At mouth of Blue River, lat. 39°, long. 108° 40′.
Green River, " . .	3873*	Beckwith.	River Valley, same lat., long. 110° 40′.
Green River, Utah . . .	6230	Fremont.	Lat. 41° 47′; long. 110°, 5′.
Summit of Central Plateau .	7490	Fremont.	Lat. 42° 24′; long. 109, 26′.
Wind River M'ts, Oregon .	10,000	Fremont.	Av. of Range; lon. 110°, lat. 43°.
Fremont's Peak . . .	13,570	Fremont.	Highest point of Wind R. Mts.

† The altitudes of this plain are somewhat discrepant, the lower part is believed to be intermediate between the measurements of Gray and Pope, though much nearer to the first, probably 3000 feet nearly. That of Marcy is clearly too low; from the length of line and the number of superior instruments used by Capt. Whipple the altitude cannot be much less than 4000 feet at any point at that meridian.

Locality.	Altitude. Feet.	Authority.	Remarks.
Plain at Sources of Missouri River and Snake River† .	5000	*Est.*	Lat. 44° to 45°; long. 110° to 111°.
Fort Benton, Mo. River . .	2663*	Doty.	Lat. 47° 50′; long. 110° 36′.
Clearwater River, Brit. Am. .	900	Richardson.	Between Saskatchawan and Athabasca Rivers; lat. 56° 43′, long. 109° 59′.
Fort Chippewa	600	Lefroy.	Lake Athabasca, and gen'l level of Brit. Am. in its vicinity. Lat. 58° 43′, long. 111° 48′ 45″ (Lefroy).

The following are important points near this meridian on each side and not represented in the above list.

El Paso, N. M.	3810	Wislizenus.	
Jornada del Muerto, N. M. .	4452	Do.	Desert of Rio Grande Valley.
Albuquerque, " . .	5032*	Whipple.	Valley of Rio Grande.
Santa Fe, " . .	6846	Emory.	Plateau at East of Rio Grande.
Fort Massachusetts, N. M. .	8365*	Beckwith.	San Luis Valley of Rio Grande.
Sangre du Christo Pass, N. M.	9852*	Beckwith.	East of Fort Mass., Rocky Mts.
Coochetopa Pass, N. M. . .	10,032*	Beckwith.	West of Ft. Mass., Sahwatch Mts.
Border of South Park . .	10,430	Fremont.	Separating it from Ark. River.
Border of North Park . .	9000	Fremont.	Separating sources of Platte from those of Grand River.
Grand River at Old Park . .	6700	Fremont.	Debouche of Grand River from Central, or Old Park.

115TH MERIDIAN.

Fort Yuma, Cal.	120	Parke.	A large area near the Gulf of California is nearly at sea level.
Colorado River	385*	Whipple.	Lat. 34° 52′; immediate valley.
Colorado River	1140	Sitgreaves.	By aneroid barom., lat. 35° 9′.
Mountains east of Colorado .	4378	Sitgreaves.	Pass to the Colorado from the east; lat. 35° 25′; lon. 114° 30′.
Basin of Mohahve River . .	1135	Williamson.	South. point of Great Basin w. of Colorado; lat. 35°; lon. 116°.
Dry Lake	2388	Williamson.	S. W. terminus of Great Basin; lat. 34° 40′; long. 118°.
Rio Virgen	4060	Fremont.	At old Spanish trail; lat. 36° 41′.
Humboldt River Valley, Utah .	6506*	Beckwith.	At its source in Humboldt Mts.
Humboldt River Valley, Utah .	4200	Fremont.	At its lowest point, lon. 118° 30′.
Pass of Humboldt Mountains .	6579*	Beckwith.	Long. 115° 30′.
Great Salt Lake	4238*	Beckwith.	Lat. 40° 41′; long. 112° 42′.
Valley of Humboldt River .	4152	Fremont.	At the Cal. road; lon. 118° 30′.
Valley of Snake River, Oregon	3138	Fremont.	Near *Fishing Falls;* lon. 114°30′.
Salmon River Mts., Oregon .	5000	*Est.*	A mass of mts. E. of Snake Riv.

† This plain is much the same in altitude and general character from near Fort Hall northeastward over the Rocky mountain divide to the sources of the Missouri. Fort Hall is at 4500 feet, and most of the half desert prairies northeastward are probably not more than 500 feet above it.

Locality.	Altitude. Feet.	Authority.	Remarks.
Kooskooskia, Oregon . .	2000	*Est.*	A plain into which the Bitter Root Mts. decline westward.
Clark's Fork of Columbia .	2100	Stevens.	Long. 115° ; lat. 47° 30′.
Cantonment Stevens . .	3412*	Mullan.	Lat. 46° 20′; long. 113° 55′.
Spokane Plain . . .	2182	Stevens.	Lat. 47° 30′; long. 117° 30′.
Rocky Mountains . . .	8000	*Est.*	At the crossing of the 115th mer.
Edmonton House, British Amer.	1800	Richardson.	Lat. 53° 40′; long. 113.
Fort Resolution, British Amer.	500	Richardson.	Lat. 61° 10′; long. 113° 51′.
120TH MERIDIAN.			
Coast Range of California .	3500	*Est.*	Aver. alt. opposite Tulare Lakes.
Kern Lake	398	Williamson.	Tulare Lakes, lat. 35° 10′.
Passes of Sierra Nevada . .	4700	Williamson.	Average of four.†
Fort Miller	402	Williamson.	Average of San Joaquin Valley.
Sierra Nevada	10,000	*Est.*	Average of range, lat. 35° to 38°.
Sierra Nevada	12,000	*Est.*	Average of range, lat. 38° to 42°.
Fremont's pass. of Sierra Nevada	9338	Fremont.	Lat. 38° 44′; long. 120° 28′.
Pyramid Lake, Utah . .	4890	Fremont.	East of the S. Nevada, lat. 40°.
Broad Plain of Sierra Nevada .	5250*	Beckwith.	Central to the range, lat. 40°.
Madelin Pass of " " .	5667*	Beckwith.	Lowest pass of Sierra, lat. 41°.
Blue Mountains . . .	5000	Fremont.	Pass., lat. 45°40′; lon. 117° 30′.
Columbia River . . .	350	*Est.*	At Walla Walla, lon. 119°, 409 ft.
Yakima River	1782*	Mowry.	Plain in bend of the Columbia.
Fort Okonagon . . .	810*	Mowry.	North branch of Columbia.
Rocky Mountains, Brit. America	8000	*Est.*	
Dunvegan " " "	1600	Lefroy.	Aver. of country near, lon. 119°.
Fort Simpson " " "	400	Richardson.	Lat. 61° 51′; long. 121° 51′.

The country represented by these lines is generally greatly elevated, and it is clearly wholly unlike that east of the 105th meridian. Each of the lines begins and terminates at low points, and British America is all low, with the same system of plains however, and the same slope, the line of which crosses the meridians in a diagonal for all points north of lat. 43°. From the east and northeast we have a gradual slope and immense plains to the foot of the Rocky Mountains, a slope which Richardson gives as two feet to the mile from the Rocky Mountains to Hudson's Bay,‡ for the last six hundred miles of the distance. That of the plains in the United States is quite the same for the northern portion, though still irregular, and much greater at the extreme south. But in the middle latitudes the mountains are higher, and the base from which they rise is proportionably elevated. Each of the lists shows this central district of

† The average of four passes, lat. 34° 45′ to 35° 50′, long. 118° to 119° ; Tejon, 4256, Fremont's Pass 4020, Williamson's, 5330, Walker's, 5302.

‡ The general descent of the Eastern slope of the Continent to Hudson's Bay from these two localities (Carlton House, and Isle a la Crosse Fort) may be reckoned at little more than two feet to the mile.—*Arctic Expedition.*

greatest altitude very strikingly, and those of the 105th and 110th meridians, and their vicinity, are but fair representatives of the whole country there. The crescent outline of these central altitudes, as approached from the east, is preserved at the south by the presence of the Rio Grande and Gila River valleys, though the mountains east of the first river, and a range west of it at the sources of the Gila, are so high as to affect the climate of the vicinity very much. From the 32d to the 30th parallels both these ranges are low, and here the more elevated districts are plateaus rather than abrupt mountains; but in Sonora, at the 31st parallel, they have begun to rise again in a rough chain which extends southeastward through Mexico and soon has an elevation twice as great as the most elevated plain at latitude 32°.

This great central mountain range has, as said before, some Alpine features at the Parks and at the Wind River Mountains, but its general characteristics are best described as Asiatic; that is, it is dry, rough, and volcanic. The whole basin region lying between this and the Sierra Nevada and coast mountains of the Pacific is similar, and in such a country precise slopes and configuration are of little importance. With the determination that it is generally high and rough, and bounded by mountain chains of great elevation, a climate in a certain sense uniform may be relied upon without much regard to particular features of exposure. In truth the altitude is of much less importance in these basin systems than elsewhere; in Asia the Caspian and Aral Seas differ little in climate from the Mongolian basin, though the first are near the level of the sea, and the last as high as Great Salt Lake of the United States. And in the United States the country at the head of the Gulf of California and at the sea level is like the whole basin region—differing only in degree of heat perhaps—which rises to 5000 feet elevation in some of its minor basins, and sinks again to less than 500 on some of the plains of the Columbia. North of the Columbia the two chains of mountains converge and the basin district ceases, and though on a scale smaller in every respect, it is still central to the latitudes to which the basins of Asia are central. The plains of British and Russian America are like the plains of Siberia in a similar comparison.

The mountains west of the North American basin may be designated as Alpine, for distinction, or as contrasted with the principal portion of the Rocky Mountains in their degree of humidity, the abundance of snows and rains, and the degree of reduction of temperature. They are like the mountains of the west of Europe, while the others have many features like the interior chains of Asia. A part of the Sierra Nevada Mountains of California must be excepted from this rule, as

they fall in latitudes so low as to bring their correspondence in Spain and Northern Africa, where the Alpine characteristics do not exist for the eastern continent. But from the parallel of the Alps themselves, or for the portion north of the 42d parallel, the Pacific coast mountains change abruptly or rapidly through the degrees of this transition, and at 50° north latitude they are quite like those of western Norway. All these are high and abrupt, with narrow and deep valleys in the interior, and with low plains toward the sea. The topography is as irregular as may be imagined, and all the features important in climatology are local.

NOTE.—In illustration of this notice of vertical configuration I will add Humboldt's resume of the altitudes of the great central American plateau as they first struck him on receiving the determinations of Fremont and Wislizenus in continuation of those made by himself in Mexico. "It will be seen perhaps with surprise, that the elevated plain which forms the broad crest of the Mexican Andes is far from sinking down, as has long been supposed, to an inconsiderable height. I give here for the first time according to the measurements which we at present possess, the elevations of several points forming a line of leveling from the City of Mexico to Santa Fé."

	Feet.		Feet.
Mexico	7990	Zacatecas	8040
Tula	6733	Fresnillo	7244
San Juan	6490	Durango	6848
Queretaro	6363	Parras	4985
Celaya	6017	Saltillo	5240
Salamanca	5761	Bolson de Mapimi	3837 / 4476
Guanaxuato	6836		
Silao	5910	Chihuahua	4638
Villa de Leon	6133	Cosiquiriachi	6273
Lagos	6376	El Paso del Norte	3812
Aguas Calientes	6261	Santa Fé	7047
San Luis Potosi	6090		

"If we consider the difference of latitude, (16°, or in a right line 960 geographical miles, 1112 statute miles) we are led to inquire whether there be in any other part of the whole globe a similar conformation of the earth equal in extent and elevation to the highland of which I have just given the leveling, and yet over which four-wheeled wagons can travel as they do from Mexico to Santa Fé. It is formed by the broad, undulating, flattened crest of the chain of the Mexican Andes, and is not the swelling of a valley between two mountain chains." (*Aspects of Nature.*)

PROFILE OF ALTITUDES FOR THE WESTERN COASTS OF THE TWO CONTINENTS.

For the purpose of contrasting the general altitudes presented in approaching the temperate latitudes of each continent from the west the design of Plate XII. has been introduced. In this the distance from lat. 25° to lat. 62° 30′ north has been drawn with the altitudes projected from a base which may, for practical purposes, be regarded as a nearly north and south line. It is probable that no great modifi-

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cation of the effect sought to be illustrated here, or of the influence altitude alone has upon the climatology of the temperate latitudes if presented as a barrier to westerly winds, results from the irregular trend of the mountains of either continent. The distinctions of longitude have therefore been disregarded in projecting these heights, except where the distance is considerable, in which case, retaining the precise altitude, it has been intended to throw them in some perspective by diminishing the heaviness of the lines. The positions of all these are, indeed, so well known that the name attached sufficiently indicates the position in longitude.

The first view of this illustration shows that the contrast between the two continents is extreme. On the west of North America an immense and almost unbroken wall stretches the entire length of the coast in temperate latitudes; the Rocky Mountains, the Cascade Range of Oregon, the Sierra Nevada, Coast Range, and plateau and mountains of Sonora successively overlapping and blending for the entire distance. This wall is, when thus projected, shown to be a more complete barrier of separation from the atmosphere of the Pacific than before seemed probable; its average being fully ten thousand feet for the middle portion and that which is the well known belt of prevalent westerly winds. The equivalent of nearly ten inches of the barometric column, or nearly one-third of the weight of the atmosphere is thus confined, in a general sense, or prevented from following a regular course of superficial circulation toward the interior. For similar portions of the European coast there is scarcely any obstruction. The mountains of Norway form a decided barrier at the extreme north, but from these to the north of Spain there is practically no obstacle to the most free intrusion of sea influences and westerly winds short of the Alps. These are so far in the interior, however, that they cannot be supposed to have any considerable influence of this sort. They are also quite an isolated mass, and not a chain comparable with the great chains of Asia and North America. Even in Spain the mountains are not continuous along the coast. The ranges all lie in a different direction from those of North America. The Mediterranean is also but little shut in, and the great desert of Africa opens directly to the Atlantic at the west. The generally low coast of Europe appears very strikingly in this sketch, and its peculiarly favorable exposure to the softened atmosphere from the Atlantic there warmed by the Gulf Stream is seen to be the ready solution of much of the difference between the climate and cultivable capacity there, and that on our own west coast.

It may be thought that this sketch with its explanation begs the question in regard to the existence of a belt of westerly winds for

these latitudes, but it verifies that view of the circulation rather, in the character of independent evidence. Comparing the two continents we find one presenting an enormous wall of elevated plateaus if not of mountains, and the other practically none of these. The first has deserts and Asiatic features at the first eastern foot of this wall, however near that may be to the sea, and along the summit plains and basins first encountered, and the second has fifty degrees of longitude of a climate ranging from oceanic or maritime, to one merely continental, before the Asiatic or desert features appear in any degree. The mountains are clearly the main immediate cause of the difference, and they can only cause such a difference under the hypothesis of prevalent and constant westerly winds at these latitudes.

OUTLINE CONFIGURATION.

The outline configuration of the continent remains to be considered, and this is clearly of the highest importance in Climatology. The position and shape of the continental masses form the greatest agency in controlling the distribution of heat, acting not only by the simple presence of the body of land, but as the director of oceanic currents, and the defective views in regard to what this agency is, have done much to complicate climatological phenomena. The presence of a greater land surface in the northern hemisphere is undoubtedly the cause of its greater measure of heat, and of the consequent transfer of the centre of the system of atmospheric circulation to a point far north of the geographical equator. By continuing the application of the analogy so apparent in contrasting the northern and southern hemispheres, we find sufficient reason that the central portions of the eastern continent, at least, should be warmer than like latitudes in North America, and they are thus warmer. From mere mass, therefore, if the assumed cause of the difference of the temperature north and south of the equator be the true one, we have a climatological difference of some tangible measure between the two continents of the northern hemisphere at once decided. There is abundant reason for this accumulation of heat in low latitudes where the heat transmitted by the sun is great at all seasons, and the large masses of land in Africa and Asia in low latitudes, and favorably situated to promote accumulation of heat, undoubtedly add greatly to the heat of the south of Europe and of Central Asia. That the effect of mass in higher latitudes, where the proportion of radiating or refrigerating time may be much greater than that in which heat is received from the sun's rays, may be wholly different, is also clear; and the great expansion of the American con-

tinent at the higher latitudes exaggerates the difference caused by the diminished mass at the south. The Arctic and sub-Arctic regions are therefore colder than those of Europe and Asia. This last effect is, however, more decidedly confined to the latitudes in which it originates than the other, or the cold at the north influences lower latitudes less than the heat at the south would influence the higher latitudes. The refrigeration at the extreme north of this continent is excessive in winter, and there is no accumulated or accumulating heat at the south to balance it, as the land area narrows off so rapidly—there is no Africa, Arabia, and India, to compensate our Siberia, and consequently the continent as a whole is below that of the eastern hemisphere in temperature. The eastern hemisphere has a very large land area at the border of the tropics while this has very little, and, as the effect of land areas to increase the temperature by accumulation or to diminish it by radiation depends wholly on the sun's altitude, the middle latitudes may be softened in winter temperature by land on the south in greater proportion than they are refrigerated by land at the north, and such is evidently the case with the climate of the south of Europe.

The result is that the measure of heat does not differ greatly for the middle latitudes, and the vicinity of the Mediterranean; and that it appears most decidedly in a higher temperature in the low temperate latitudes, and in the great area of the districts so heated. At many points the medium isothermals correspond.

If this view of the effect of mass alone is correct, all the contrast between the two continents which is not clearly explained otherwise is fully accounted for. The relations of mass on the western coast, would require a line southwest from Russian America for that coast, instead of one southeast and east-southeast; and the formation of a second Africa from a point off San Francisco and reaching nearly to the Sandwich Islands—the gulf of California corresponding in position with the Red Sea. There are many points of similarity even now in the climate of these two seas, and these would be rendered general instead of local by some great source of influence like that now controlling or modifying the heat of the middle latitudes of Europe and Asia.

The eastern coasts of the two continents have the same trend and nearly the same extent, though the American coast springs from a point, in Central America, rather than from a wide base as in the south of Asia. There is not much difference in climate on that coast, and the effect of outline configuration is the same in both cases, and in both it is evidently one tending to exaggerate the normal tropical features of heat and humidity in the lower latitudes, and to develop

extreme continental effects in the higher latitudes. As a consequence we have an excess of heat and humidity at the borders of the tropics in both cases, due in part to confined and accumulated heated waters, and a rapid elimination of both in proceeding northward; with very dry and cold climates at the high latitudes, where the continental effect, as technically so designated, takes this direction. The coasts of the Gulf of Mexico and the West India Islands correspond in the first case with India and the south of China, and in the next we have Canada and Labrador corresponding with the north of China. The rigor of the climate is said by Williams* to prevent the settlement and cultivation of much of Mantchooria at 42° to 45° north latitude, and Canada and Labrador are not more, but even less rigorous in climate at the same altitudes.

For the east coast we have, then, similar lines and configuration to those of Asia; and near this coast there is the same class of sea currents, to whatever cause these sea currents may be due. Commodore Perry has recently shown the existence there of a stream of warm water strikingly similar to the Gulf Stream of the Atlantic, and if these have their origin in a confinement of the heated waters of the tropics on that side of the continent, the causes and consequences should be, as they are, similar. Whatever portion of the coast is within the influenee of this current in either case is affected similarly, and, in accordanee with the rule, the softened climate of Japan and of the islands of the vicinity, and their contrast with the continent in the same latitudes are very noticeable. The great storms at sea off this coast also appear to be like those of the Gulf Stream and Atlantic coast. Whether the current would cease with a different line of coast in either case we need not inquire in the present purpose, nor whether the hypothesis at some time proposed be true, that the evidences of high temperature and semi-tropical vegetation in Arctic America prove the existence of a current like the Gulf Stream over the then *submerged* Mississippi plain and eastern part of the continent. With similar lines of configuration on that side of the continent in each case we find similar physical phenomena in all that may control existing climates.

With the western side the configuration is not the same, and as before intimated the continent is believed to be rendered colder, relatively, by this fact, at least to the degree of the difference of land and water temperatures near the borders of the tropics; which difference may be assigned at nearly 1° of the thermometric mean. In comparison with Europe there is a further disadvantage of position

* History of China, 1853.

in the much greater distance of the coast from the warm-water current passing northward on the east coast of each Continent. Europe is directly and largely influenced by the Gulf Stream, but the Japanese Stream is too far off to be felt directly on the Pacific Coast of America; and it is, in truth, felt there quite directly in a reverse character, as the answering, or cold current—that which, in greater part, returns west of, or beneath the Atlantic heated stream, but which in the Pacific comes full upon the coast of America in middle latitudes, while the warm waters have been spent in expanding over an immense ocean surface. This result is due to position and exterior configuration, and in these two cases, in conjunction with the great altitudes of the western borders of this continent, all the difference of temperature between the two divisions of the temperate latitudes may be found. The last cause named is not so general or controlling as the first, because the cold current is a comparatively narrow mass at the point of its rising on the coast, and evidently is not felt north of the 45th parallel. The average reduction due to both causes is less than 2° on the mean temperature.

The position of the Continents relative to the prevalent winds of the temperate latitudes is of great importance, and necessarily a part of the configuration. In referring to it it becomes necessary to assume what is not universally conceded, namely, a belt of westerly winds as the great characteristic of these latitudes. In proof that such a belt exists the difference of temperature of the opposite coasts of both seems a conclusive evidence. If no atmospheric circulation modified this distribution by conveying the heated or refrigerated air in some direction there is no reason for any such difference as we find to exist. The maximum of continental effect in refrigeration and aridity should be found in the centre of the continent, and its degree should be as great on the west as on the east. But the differences are scarcely less extraordinary at the west of North America as compared with the east—Sitka with Labrador—than in the comparison of England and Kamtschatka, England being directly influenced by the Gulf Stream. Why it is so influenced is seen in this atmospheric circulation itself, which clearly carries the air eastward for all these temperate latitudes; the heat and humidity of the masses transferred being gradually exhausted until the maximum of continental effect is thrown nearly to the eastern coasts of both. This very evident fact would be conclusive if the surface wind gave no evidence in conformity, since a superior system, or superior aerial currents would alone be sufficient to produce a marked result. But we have the observed winds of all the middle latitudes to confirm the assumed circulation. Three-fourths of the number and force of all the winds

recorded at 35° to 50° N. latitude are from some point into which west enters, and their average resultant, as traversed in an accurate manner, is within two or three points from due west. The greater facts of temperature distribution between the opposite sides of the continent have their full solution here.

Under this system of atmospheric circulation the altitude of bordering districts becomes more important than before, and it may be said, in brief, that the great altitude of the mountains and plateaus nearly bordering our Pacific coast develop at once an extreme continental effect, and aid in rendering the continent unduly cool and dry. This is the remaining cause of difference between Europe and America, and in the colder seasons its influence is very decided, as may be seen in a brief reference to the facts of temperature and rain distribution here.

In the view here taken of the system of atmospheric circulation lying at the base of the climatology of these latitudes, the great altitude of the continental mass near the Pacific by no means alters the course of that circulation, or shuts off the west wind of the upper and more general movement by any impassable wall. These winds are as regular as before, or elsewhere, though they are necessarily somewhat cold and deficient in moisture at that elevation, and therefore lose much of the heat and moisture they have over the ocean surface before reaching the interior. The prevalent winds are west winds at all points sufficiently elevated to eliminate the local effect, and the course of the cloud above the lower strata is equally regular. In short there is no evidence that this wall modifies the atmospheric circulation in its more general character, or in that believed to be central at the equator, though local winds and movements of a peculiar character are developed at many points, subordinate to the general one, and the low, warm, humid sea atmosphere which so greatly influences the climate of Europe is almost entirely shut off.

There is another effect of configuration which may be noticed here. It is the supposed deflection of the northeast trade wind up the Mississippi valley by the great altitude of the continental mass in Mexico. Whether such a deflection occurs or not it is difficult to say, and altitudes like those of the central regions of Mexico may be found to exert a great influence on the atmospheric movements in low latitudes. It is reasonable to suppose that this normal movement may be checked at that district, and that the attraction of the area of rarefying air over these plains, as they become heated in Spring and Summer, may induce the moderate winds from the south, southwest and southeast known to belong to nearly all the Gulf coast and Mississippi valley during the warmer months. The outline configuration and the effect

to some extent, while the sudden and great increase of temperature there is the inducing cause of the movement.

The vertical configuration of the Mississippi Valley is peculiarly favorable to the ready development of such a result, as it is particularly open and low on the south everywhere. The whole of the immense plain sloping to the Gulf of Mexico, perpetuates the conditions first instituted at its southern border, and the prevalent south, southeast, and southwest winds are but the necessary incidents of the high temperature of the plain, in the light aspirate degree in which they blow for the warmer months. They are not identified with a large mass of air, and are almost always crossed above by the clouds borne on the prevalent west winds, which may be set down as well defined at and beyond the thirty-fifth parallel.

It must still be said that the relation of physical geography to climatology is confused and unsatisfactory. A greater number of points of observation is required in the recently known districts of North America and Asia, not only of what the climate is, but of what the actual physical features are. The southern hemisphere must also be known, and its simple relations of structure and position of the land masses and the sea, must be compared and tested by the analogies of this hemisphere. It can then be better known what value to put on certain analogies, and particularly upon the modifications attributed to belts of westerly winds in the temperate latitudes.

CONFIGURATION AND SURFACE OF EUROPE AND ASIA.

The reference to the configuration of the temperate latitudes of the eastern continent will be made very brief, and to contain no more than is essential to a clear comparison with our own. The entire north of Europe is an immense plain, embracing Ireland, most of England, half of France, the north half of Germany and the states in that vicinity, Sweden, and nearly all of European Russia. In all this northern area, which at the west of France and on the Black Sea comes down to the 44th parallel, though the German mountains go to 50° of latitude in Central Europe, there are only the comparatively unimportant mountains of Wales and Scotland, the Norwegian chain, and the Ural Mountains in the extreme northeast. In the south of Russia near the Austrian frontier a cold and somewhat elevated plateau exists, which soon rises into the Carpathian Mountains of Gallicia in Austria. In Central Germany and Saxony similar features exist, some portion of the Bohemian Mountains lying north of the 50th parallel. In France the plateau is central, and it rises to mountains in the east,

along the Rhine, and to those of Switzerland, to the Auvergne in the centre, and the Pyrenees at the south. The hills of Ardennes and the chain of the Vosges are the most northern, the first being less than 1200 feet in height, and the last an average of near 3000. The Auvergne is an irregular mass of volcanic mountains, averaging near 3000 feet, but with summits over 6000 feet. The central plateau of France is perhaps 2000 feet, and the mean elevation of the non-mountainous parts of France is stated by Humboldt to amount to less than 480 feet.*

The principal part of Europe comparable directly with the climate of the United States belongs to this great plain, and to the first system of highlands bordering it on the south. In Russia the rivers of the Baltic and Black Seas rise in a low, interior, dividing plain, quite like that separating the lakes and the tributaries of the Mississippi in Illinois. The division line is in what is called in some parts the Valdai Hills, running northeastward from the frontiers of Poland to the Ural Mountains, the average height of which is 800 to 900 feet, the highest point 1100 feet, and the highest between the Baltic and Black Seas but 1328 feet.† The lowest dividing plains at the head of the rivers fall to 600 feet. In the south of Silesia there is a chain 2200 feet in height, and in Saxony one of 1000 feet, and these are the first considerable altitudes above the very low plain of the Baltic in the north of Germany.

The mountains of Norway are lofty and formidable, yet mainly made up of irregular summits shooting up from lofty plateaus; they are of great climatological importance in so high a latitude, and they render the east of Norway and the west of Sweden almost uninhabitable. The extreme points of the chain are in 59° and 70° N. latitude, at the extreme borders of the temperate zone, and the altitude of the plateaus and mountains renders the climate an Arctic one, except at the immediate coast on the west.

The mountains of the British Islands are all low, and they would have very little climatological importance in the latitudes of the United States. At their high latitudes, however, they are the cause of great distinctions, especially in regard to the quantity of water falling in rain. Scotland is particularly rough; a chain of hills at the southern border averaging 2000 feet above the sea, the Grampian Hills in the centre averaging 3000 feet, with summits at 4390; and in the north, rough hills at 1500 to 2000 feet. The Grampians and northern hills are barren and desolate, but all the lowlands highly cultivable.

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* Cosmos, Physical Geography.

† Article Russia in Lippincott's Gazetteer.

In the west of England and Wales, there are mountains quite similar in altitude to those of Scotland, and with similar climatological consequences.

The relatively small importance which the mountain systems of Europe have in making up a continental elevated mass is forcibly shown by the researches of Humboldt on this point. He states* that the mass of the Pyrenees, of which the elements as derived from the altitude of the summits and the area of the base, are well known, would not, if distributed over the area of France, elevate its mean level but about 115 feet. "The mass of the Eastern and Western Alps would in like manner only increase the height of Europe about twenty-one and a half feet above its present level." This is a forcible statement of their unimportance as an obstruction of atmospheric circulation, and, notwithstanding their prominence as single mountain altitudes in a profile sketch, we see that they bear no comparison to the uniformly elevated mass of the western side of the North American continent.

In this connection Humboldt also gives the mean altitude of the continents generally, placing that of North America at 748 feet for the centre of gravity of the entire volume of land, and that of Europe at 671 feet above the sea. From the facts disclosed by our recent explorations it is clear that a decided contrast exists between the altitude of North America and that of Europe, and it is probable that it is very nearly as great as that of Asia or South America, which Humboldt places at 1132 and 1152 feet respectively. So far from the Rocky Mountains forming but a single chain of elevations or of mountains alone, they are rather the crests and representatives of lofty plateaus. Regarded from the base out of which they rise, and only in the measure of their altitude from it, they are of secondary importance. The area of the elevated country is seen at a glance to be very large, beginning, as it does, near the 100th meridian and occupying all the continent westward, except small tracts at the coast, and a part of the great northern plain.

With one feature of surface and configuration often found locally important in Europe, and generally entering largely into the notices there given of climate in this connection—the coast indentations, bays, fiords, &c.—we have so far had scarcely anything to do. The most that can be said of these agencies in America is that they give a wider belt subject to maritime influences, and so extend the range of coast climates a little. In Europe they do so much more largely, and among the preponderating local influences this has an important place.

* Cosmos, Physical Geography.

In Europe there are interruptions of the uniformity of the coast outline of a more important character than anywhere else, and the North Sea, the Baltic and its approaches, with the Mediterranean and Black Seas break up the mass of land very much, and bring a much greater proportion of it under oceanic influences than would otherwise be so distinguished.

Humboldt and Guyot have attached great importance to this one of the physical features of Europe, and particularly to the presence of the Mediterranean and its tributary seas in the south of Europe and in the midst of the cultivable latitudes. Here, at the south, the sea is continuous on both sides of the narrow line joining the continents, and we may as reasonably suppose the great mass of the continent of Africa there to be exceptional as the presence of the sea.

The interior lakes of North America and some of the inner seas of Europe and Asia have a large local influence on the climate, if not a general one. They soften the extremes and modify its continental character apparently in the direct measure of their amount of surface as compared with the sea itself. In the United States the great lakes are favorably placed to modify some of the continental extremes which might be supposed to occur there otherwise, but there is a point equally clear, when the matter is examined, which takes the causation from these masses to a great extent. It is that they are a consequence of abundant rains and an equable temperature, and could not exist if extreme continental features of climate were ever fairly developed there. The interior seas of Asia have no external drainage, and the great basin region of the United States is similar. Yet from the area of the great lakes, which are elevated and full water collections on a level with the surrounding country, there is a great volume of drainage in the St. Lawrence river. The primary conditions of climate are not, therefore, analogous to those of the Caspian and Aral sea region of Asia, and we cannot rank the United States east of the Rocky Mountains as extremely continental in regard to humidity.

As said elsewhere its comparison is with China alone, and its great oscillations of temperature, atmospheric weight, &c., are due more than anything else to the character of the storms and disturbances, and to the great area over which these act symmetrically and uniformly.

III. GENERAL CHARACTER OF THE CLIMATE OF THE EASTERN UNITED STATES.

It is necessary to make a distinction of a very decided character between the parts of this continent separated by the Rocky Mountains, though the idea of this distinction has hardly yet entered into the received views of the North American climate. It is still described under the characteristics which belong only to the area east of the great plains, and the homogeneous character belonging to much of this great extent of surface is that recognized in Europe as the North American climate. Now that we have found this to differ so extremely from the interior and Pacific districts, it is necessary to describe it separately, and to designate it as the eastern area of the United States.

So recently as the production of Guyot's able work on Comparative Physical Geography* the distinction made between the old world and the new was to assign to the new *oceanic*, and to the old world *continental* climates; the prevailing character of the Eastern States and the Mississippi Valley being taken as the type for the whole country. The great expanse of these plains gave reason for this distinction, in the then unknown condition of the interior and Pacific coast, but it is now clear that the proportion of arid and continental districts and climates is as great here as in the old world. The position of the plains exposed to oceanic influences is reversed, however, and instead of the extensive low areas belonging to the west of Europe our western coast is very narrow, and the Mississippi plain is, to some extent, the equivalent of the European plain.

But the climate of the Mississippi valley or plain, and of the eastern side of the continent generally, is not oceanic strictly; and it differs radically from the oceanic climates of the west of Europe. It has its equivalent only in a similar continental position, or in China; which is, unfortunately, too little known to aid the illustration much. As a whole, the North American continent differs little from the old world,

* Guyot's Earth and Man, p. 224, 1850.

except in the comparative areas embraced by the several divisions. Our oceanic districts on the west are very narrow and unimportant compared with the immense and fertile areas of like position and climate in Europe; our interior and extreme districts are differently placed from those of Asia, but in other respects they differ little; our eastern areas, which are properly neither interior nor oceanic, are comparatively larger and more important because of the existence here of a great interior plain opening southward to the tropical heat and moisture, and partaking to some extent of tropical peculiarities. Though the area of China is very great, and its climate clearly not unlike that of the United States in the same latitudes, it does not hold so important a relation to the continent on which it is found.

The early distinction between the Atlantic States and the Mississippi valley has been quite dropped, as the progress of observation has shown them to be essentially the same, or to differ only in unimportant particulars. It is difficult to designate any important fact entitling them to separate classification; they are alike subject to great extremes and to the same extremes, they both have strongly marked continental features at some seasons, and decided tropical features at others, and these influence the whole district similarly, without showing any line of separation. At a distance from the shore of the Gulf of Mexico sufficient to remove its local effect, the same peculiarities appear which belong to Fort Snelling and to Montreal, as well as to Albany, Baltimore, and Richmond. On the immediate coast of the Atlantic a local oceanic climate exists, but it is always blended with the continental features which belong to the climate of this part of the continent generally.

The principal feature of this area as a whole is its adaption to a great range of vegetable and animal life. It is extreme without being destructive, and it brings in tropical summer temperatures and profusion of rain, with low winter temperatures, near to those of the extreme continental climates; and the result is a condition extremely favorable to the acclimation of tropical or semi-tropical plants and animals. This is the great advantage the area of the Eastern United States and Mississippi Valley undoubtedly has over Western Europe; or the distinction, if not an advantage. The peculiarities which belong to it as such are those which it is proposed to notice here.

The semi-tropical summer is perhaps the most noticeable feature of the measure of heat here. We find a mean temperature of 70° for the three months at Salem, Mass., at Albany, in the interior valleys of New York, at the south shore of Lake Erie, Southern Wisconsin, Fort Snelling, and Fort Benton, on the Upper Missouri. At Baltimore, Cincinnati, and St. Louis, we have a mean of 75°; and over an

immense area bordering the Gulf of Mexico, and reaching north, nearly to the 35th parallel, we have a mean temperature of 80° or more, which is considerably above that of many portions of the tropical seas of Central and South America. And this high temperature is associated with the peculiar features of the temperate climates in other respects; with equally distributed, yet abundant rains, and with the high curve of daily changes which belongs to the same districts. It is simply an excess of temperature and of humidity, engrafted on, without otherwise changing, the characteristic laws elsewhere belonging to much lower temperatures. To illustrate this point, the averages of the highest and lowest temperatures observed at two or three points, may be given for these months:

		June.	July.	August.		
Key West . .	Max.	88.4	89.7	89.7	Average range	13°.7
	Min.	74.5	76.	76.		
Charleston .	Max.	89.	90.5	89.	" "	22°.1
	Min.	66.5	72.	70.3		
Baltimore . .	Max.	92.	94.	91.	" "	33°.7
	Min.	54.	62.	60.		
St. Louis . .	Max.	95.	95.	95.	" "	39°.7
	Min.	51.	58.	57.		

These are all averages derived from long periods, and they may be taken as quite correct representatives of the measure of daily range of temperature for these points. They show that range to increase very largely in going northward to St. Louis, while the maximum temperatures also increase rapidly, and so rapidly that the mean for the three months at St. Louis is but three and a half degrees below that at Key West, which has a full tropical climate. If this measure of heat occurred without this great daily range, it would make the climate simply tropical, but occurring under the existing circumstances, it renders the country capable of great elasticity in the adaptation of vegetable and animal forms. Cotton, Indian corn, and the cane, find their natural climates here, but not elsewhere, in any considerable degree, beyond the tropics; and the native canes and grasses of this genus, found in the south Atlantic States, and in the Mississippi Valley, to points some distance above Cincinnati,* prove the adaptation to be perfectly natural and not forced.

The excess of summer temperature in the United States appears more decidedly peculiar, because of the contrast first and most readily drawn between this and the cool summers of Europe. Its proper

* In Am. Journ. of Science, vol. xxix., Dr. Hildreth says: "As late as 1805, the bottoms of the Big Sandy River (of Kentucky), were clothed with cane, and boats visited that stream, for the purpose of collecting the stems of this gigantic grass." It also grew on the Potomac River, at Washington, before the settlement of the country.

comparison is with China, and to some extent with the district of the Black Sea, and the northern valleys of India. China is very little known, and it is impossible to say whether the correspondence of position has an entire correspondence in climate attending it, but so far as it is known the measures of summer temperature are more rather than less excessive, compared with the same latitudes here. Pekin at 40° N. latitude, has a mean summer temperature of 76°, which is two or three degrees above that of Philadelphia, the latitude and position of which is the same. At Nangasaki, Japan, we find a mean of 80° for the summer, its position corresponding with that of Charleston, which has the same measure of heat for this season. Canton and Key West again correspond, both being essentially tropical.

The excess of heat which belongs to the Eastern United States for a part of the year would give a distinctively continental climate if it were not associated with profuse rains, and with a degree of humidity which softens some of its features, and at times institutes tropical uniformity. Such periods frequently occur in the warmer seasons, over the whole area, and particularly in the Mississippi Valley—frequent and profuse rains occurring with great humidity, and with a very small range of temperature for the day. At New Orleans these periods often become almost perfectly tropical, with daily rains at midday, clear evenings and mornings, and a very low curve of daily range of temperature. These periods are wholly irregular at all other points than the last named, though they are found in this irregular form, even to Montreal and Quebec, if not to the borders of Hudson's Bay. Vegetation has extraordinary luxuriance at such intervals, and it then puts on a free growth as in the tropics, and one wholly different from that of extreme continental climates, as these are defined on the old continent. Fruits of delicate structure, including most grapes, are often decided sufferers from this peculiarity, and this is a permanent difficulty in the way of successful vine cultivation in all the district described.

The district embraced by this uniform climate is very large. Excepting the points of local influence at the coasts and near the great lakes, it may be said to include all the continent east of the 100th meridian; at which line the arid and extreme character of the plains sets in. Of this district nearly the whole surface may be practically regarded as level, and very little elevated. The mountains which occur do not break in upon the climate except by reduction of temperature, simply, or by the changes caused by altitude alone. They do not shelter or expose either side, nor cause any contrasts in the character of productions respecting them. Western and Eastern Virginia differ little, and probably not at all from the influence of the

intervening ranges of mountains. It is still more decisively so in Pennsylvania, and at the southern extremity of the Alleghany ranges, where Tennessee may be contrasted with North and South Carolina and Upper Georgia. This absence of interruptions of the general condition, even where mountains of considerable height occur, is one of the most distinguishing features of the North American climate, and that which, more than any other, requires it to be treated as a separate district for the area east of the plains.

As an associated feature of the uniformity just alluded to, the changes of temperature, and the oscillations of every sort, strike over the eastern United States as changes would over any plane surface; that is, they are symmetrical and uniform, and knowing what they are at a few places we may easily infer what they have been at all. Thus if a great degree of cold occurs at St. Louis on one day, and at Philadelphia two days afterward, or at any interval whatever, we may be certain that the whole intervening district has been similarly affected. So of a barometric depression or variation, or of a great storm, or of particularly severe winds. Though the changes occurring in one part may not be felt at an opposite point,—as, though it may be twenty degrees below the average temperature for any period at Charleston, it may be as much above that mean at Albany or Montreal—the conditions, whatever they are, affect the intervening districts symmetrically, and are participated in at all places according to the distance from the extreme points. This may be the case to some extent in other climates, or it may be so with some of the greater changes, but here it is characteristic of all, and it contrasts extremely with the abrupt transitions, and the predominance of local changes in southern and central Europe, and on the west side of this continent, so far as known.

This symmetry of the changes which is characteristic of the United States is particularly favorable to the investigation of the dynamics of the atmosphere, and the laws of its storms and movements. These may be recognized at so many points in any general disturbance, and the whole phenomenon may be so well defined and bounded, that it is scarcely possible not to get a decisive knowledge of these laws from discussing the records. This discussion belongs to a particular department which will be alluded to under the head of winter storms, but it may be said here in brief what the results are.

The movements, disturbances, and changes of every sort, generally move across the country from west to east, as though they were the incident of the belt of westerly winds prevailing over most of the area. They are first felt at the western border perhaps, or they may be initiated at any point in longitude or latitude, and from this point

generally move eastward. They are felt at the most remote points eastward from one day to three days later than at the 100th meridian, when they begin so far west; though the same phenomenon is rarely identifiable across the whole country. Thus, a severe storm may occur at St. Louis, preceded by high temperature and accompanied by a low barometer, and these conditions will probably be felt farther eastward, and possibly along the whole Atlantic coast; but whether they are or not, the low temperature and high westerly winds which usually follow a great storm, are likely to follow over many districts where the storm may not have gone, and in one way or other prove the participation of nearly all the area in some of the phenomena. These sweeping general changes are characteristic of the climate in regard to storms, and there is a measure of force and movement about them quite peculiar. Both in regard to temperature and atmospheric movements, they clearly have the whole area under notice as their field, in every part of which they may occur in any degree of development.

As the greatest field where the successive changes of the elements are exhibited in the temperate latitudes, the area of the United States is particularly interesting, because particularly favorable for observation. It ought not to be difficult to ascertain from what direction and what source extremes of heat and humidity are intruded, to be removed by the paroxysms of change which accompany great precipitation in rain. These phenomena are constantly recurring at nearly all seasons here, though more limited and local in summer than at other seasons, and then, for the greater part, confined to the extremely local and unimportant phenomena of thunder showers; which, even when quite severe, may affect only a mere thread of surface for a few miles in length, and a few minutes of time.

The duration of particular conditions is somewhat greater in the district under notice than elsewhere, it is believed. Days of persistent and strong westerly winds, with the continuance of cold, and of rains and storms through two or three days, are the incidents of a large district similarly affected; and they do not belong to local climates unless they are periodic. Here, with the exception of the westerly winds, none of the conspicuous features could be called constant, as there are no monsoons, or rainy seasons, and no local or peculiar winds. There is sometimes a singular persistence or duration in the easterly storms of the whole country, and particularly of those in the latitude of Washington. These easterly surface winds are merely the incident of continuous rains from the higher strata of clouds moving from the west, or in the natural direction for the clouds and atmosphere which appear to bring the supply of moisture for these latitudes.

Some of these continued rains are distinctly identifiable through their whole course from the plains to the Atlantic coast, and the entire area similarly affected sometimes embraces two-thirds of the whole continent east of the 100th meridian.

It is scarcely necessary to cite here the proofs of the general participation of large districts in the considerable disturbances and changes occurring in the eastern United States, as the facts are sufficiently known to every intelligent reader for the present purpose. In discussing these changes themselves some instances and observations in detail will be introduced from the records, but the general appreciation of the fact is sufficient without the use of statistics here. Beginning at the northwest, or near Fort Snelling, the general succession of phenomena in the change from calm, average conditions, to the restoration of such conditions again, is something near the following: first, an increase of temperature, with winds from the south, southwest or southeast, of duration proportioned to the measure of the change that is to occur, or of from one to four or five days; a fall of barometer; a rain with east, northeast, or southeast winds during the first half of its duration; a sudden change of wind to some westerly point with a rapid reduction of temperature, high winds, and a rising barometer; and, in conclusion, a period of comparatively cold and clear weather. The nucleus or central area of this phenomenon, regarding it as a whole, or, as it may be done for illustration, as a moving body, usually progresses eastward at the rate of three to eight hundred miles in twenty-four hours; and it is quite uniformly attended by a similar succession of changes until it reaches the Atlantic coast. Sometimes this succession of events has a limited field along the great lakes, and nothing will be felt of them at Cincinnati or St. Louis. Sometimes they sweep with great violence along in the latitude of these cities as a central line, and then they are usually most severe, affecting the whole country southward to the Gulf of Mexico, particularly with the concluding phase, or the high and cold winds and the reduction of temperature.

They are also often felt at or near the Gulf, when at Cincinnati there is no participation whatever; those who suffer by a biting north wind there supposing it to come from the latitude of the lakes, when perhaps at St. Louis, even, a south wind is blowing,—the northern districts not partaking in the effects at all during any part of the change. At the colder seasons the Lake districts are often not only relatively but positively warmer than places far south of them, and this was particularly the case through the very severe cold of January, 1856, during which the thermometer did not fall so low, at the coldest, by ten to fifteen degrees at Lake Superior as at Chicago at the same

time.* This remark holds true of the changes of all periods of duration, even if continued over a month or more.

Ordinarily the changes at Cincinnati and Wheeling are continued or reproduced at Baltimore and Washington, without suffering any interruption by the presence of the mountains which intervene. A change may be exhausted before reaching so far, or it may be greatly increased in severity, but the reason in each case lies wholly in the fact of distance. Such is clearly the principle which controls the climate of all the area under consideration; and the analogies are precisely those of the agitation of any mobile fluid or aeriform mass where the degree or measure of the disturbance, with its motion, if it have one—or if, as in the case here, the fluid mass have a motion of itself carrying the disturbance along as a water ripple would be carried by a current,—controls the question how far and where its influence will be felt.

It is still true that the last phase of this circuit is often spread over a greater surface than any other, the high westerly wind and reduced temperature being longer continued and going farther than the previous heat and rain. The reason apparently is that there is a general movement from the west in these latitudes with which this phase of the change coincides, and on which it is superadded. There is something which may, perhaps, be designated as the momentum of the aerial mass at these times, and particularly when its temperature is so much reduced, and this momentum evidently carries it farther than the original limits of the agitation.

No clearer view of the homogeneous character of the climate east of the Rocky Mountains can be obtained than by the consideration of these facts of physical movement, and of all that relates to our storms and disturbances of every sort. The great winter storms are especial proofs of the uniformity of the field over which the mass of our atmosphere, and the elements of heat, moisture, and perhaps magnetism, which move it, pass through their succession of changes. It may be more clearly a natural or normal climate, also, than that of Europe; which is largely maritime, or one softened in regard to periodic and non-periodic changes more than the average for the whole earth in its latitude. The Interior climates of this continent are the extreme in opposition to the west of Europe, and, with the immense continental mass of Asia, they make up the portion

* On January 9th, 1856 the thermometer fell to 18° below zero, (—18°,) at St. Louis, while at Superior City, on Lake Superior, it was at no time in that month below —16° previous to the 26th, when it fell to —18°. At this last date the thermometer was at —25° to —30° near Chicago; at —30° at Jamestown N. Y., and at —7° at Washington City.

where the greatest measures of change occur. The oceans and the west of Europe give the minimum of range, while the east of Europe and the United States east of the Rocky Mountains, at a mean between the two extreme classes, more nearly represent the normal climates for the latitude.

The vicinity of the Black Sea in Europe, and the greater part of China proper, appear, from what is known of them, to be characterized by conditions quite similar to ours. When they are thoroughly known the entire comparison may be clearly drawn, and we may know more accurately what the normal climates are. But it has already been shown that Europe is an extreme case, and may not be taken as the basis for generalizations to apply at all places. Its exceptional position is strikingly shown by the isothermals for any season, and particularly by those for the year, and when it is remembered that the measure of heat is the controlling element, to which all others are subordinate, we must look for large departures from all the quantities there measured,—temperature, humidity, rain, atmospheric weight, and all others—and these both in the constants and in the irregular changes. Such departures are found in comparing the statistics of climatological observation there with all others in like latitudes.

It was not the purpose to do more than give an outline view in this connection, with some general definition of the district as a whole. The detail of most of its features will come up in other parts of the work, and the statistics which support the positions here taken may be found in the general mass of statistics, and in the special references. It is clear that we have in the United States a distinguishable whole of a peculiar character, into which features elsewhere called tropical, continental, and oceanic or maritime, enter in decided measures; so much so that from a single point of view the general climate may be quite reasonably set down as one and another of these, and each in turn.

The slight influence the presence of the Alleghanies has on the general climate here deserves some further notice. Abrupt differences and contrasts are the subject of constant attention with writers on European climatology, and the presence of such differences is taken as the standard or normal condition wherever mountains exist. It is matter of surprise with them to see vegetable and forest growths, and forms of cultivation, at two to three thousand feet elevation in Virginia, which differ very little indeed from those of the plains at or near sea level on each side; and no difference whatever of a climatological origin between the opposite bases. Humboldt alludes to this as

among the agencies of climatological distinctions; and particularly refers to the

> ". . . diversity of forms on the surface of the planet, such as mountains, lakes, grassy savannas, and even deserts encircled by a band of forests," . . . "blending of low, discontinued mountain chains, and tracts of valleys, as we see so happily presented in the west and south of Europe, which tend to the multiplication of the meteorological processes and of the products of vegetation."*

These generalizations are eminently true of Europe, but they apply to the eastern United States only in a limited degree. On the contrary, there is a remarkable absence of local divisions and distinctions from any cause, or in any case; and yet the number of lakes, mountains, and plains, is considerable, and they have an altitude and surface sufficient, according to European analogies, to give rise to decided climatological differences.

The features of sensible climate in the eastern United States, or the current weather, as it is termed, will necessarily be alluded to at some length in the specific comparison of European and American climates. In regard to these there is great variability in different districts, and the characteristic peculiarities of the various sections do not alter the correspondence of the greater changes that have been referred to. The Ohio valley at Cincinnati, the Atlantic coast at Norfolk, and the interior of New York at Rochester, may each be swept over by some general change,—of pressure, temperature, winds, or rain,—and influenced as uniformly as if they were all located within a circuit of a hundred miles. At Cincinnati a close and saturated atmosphere of high temperature would probably exist, at Norfolk one moderated by the sea air and more equable, at Rochester one which would have great changes from a sultry mid-day to a cool night; in each case local peculiarities yielding to changes of general symmetry, and being restored again as these pass over.

The constant movement of the higher clouds from the westward is a marked incident of this area above the 32d parallel, and though it is not distinguished from the temperate latitudes elsewhere, or from similar latitudes of the northern hemisphere, by this phenomenon, there are some noticeable peculiarities attending the movement here. All the considerable clouds and storms so move, even when appearances indicate a reverse movement. Thus the visible clouds may be driving freely from northeast, southeast, or south, yet there are in truth *subordinate* clouds, the incident of a saturated atmosphere, and of higher clouds borne from the west. They often extend but a short distance in the direction from which they appear to come, and the *horizon line*

* Cosmos, Physical Geography.

at either of these points may be seen to be clear from an elevated post of observation. Generally for the whole area under consideration the *west* is the point to be scanned to judge what immediate weather is to ensue, and the evidences of humidity and of cloud formation in the upper atmospheric current moving from the west, are the best guide to the only possible foreknowledge of the weather.

It is sometimes thought that the lower or *incident* winds in this part of the United States belong to the sea-coast mainly, or come from it, at least. It is true that they are more frequent at the sea-coast, but the reason of that frequency is only in the fact that the sea air is more constantly cooler than that inland, and thus more easily drawn inward toward a rarefied and humid area. The clouds and movements from some easterly point below belong to all the interior; the northeast chill, and the southeast warmth and humidity, as certainly attend the fall of rain from the clouds of the high westerly current at the Mississippi River, as at any point eastward, and they are always and everywhere *incidents* of the symmetrical precipitation and storms of the area east of the Rocky Mountains.

A recent writer* has graphically sketched the phenomena so characteristic of the constant recurrence of storms and rains in this part of the American climate, and the differences of the various parts of the United States east of the Rocky Mountains, in localities and in seasons, is mainly in regard to frequency of recurrence. The graphic description of Mr. Butler, is here condensed.

In the evening of a day in autumn, 1853, in passing by railroad from New York to Hartford, fragments of scud clouds became visible driving towards some disturbed atmosphere in the northern part of Connecticut, or farther; at Hartford they were visible in all directions, running northward at the rate of 25 miles an hour, and we had passed in forty minutes, from a clear, calm atmosphere, which still remained so, into a cloudy, damp air, and brisk southerly wind, *in which this scud is forming*, and running north to underlie the storm. The southern edge of the rain was met at Deerfield, and the next day was rendered very unpleasant by it.

This southerly surface wind with its scud and dampness was created by the storm at the north, as was clearly shown by *travelling with it* from a locality having a clear and serene sky, which still prevailed over Long Island Sound.

In returning south on the next day as we neared New Haven faint lines of cirrus cloud were observed low in the west, which were evidently the eastern outlying edge of a northeast storm, approaching from the west-southwest. It was then probably raining at a point 150 or 200 miles westward of the bars of condensed cirrus, and under these the wind was attracted and blowing from the northeast toward the body of the storm;—the rain would probably reach us in twelve or fifteen hours. As we approached the storm and the storm approached us, the evidence of denser condensa-

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* J. B. Butler, *Philosophy of the Weather*, &c., New York, 1856. (Introduction.)

tion at the west, and of wind from the east blowing toward it, became more apparent, and the fore and aft vessels were running up the sound before a fresh northeast breeze.

Such is the almost constant succession of the phenomena of condensation and precipitation, for the colder months of the year at least, over this great area, and the sensible climate is largely made up of this succession of incidents. On the Atlantic coast the reacting movement from the colder atmosphere, which is usually at the northeast, is more severe and prolonged in all cases, and it frequently occurs when it is not known inland, as where the degree of condensation is not great, or is quite local. On the coast, also, the temperature of the surface wind is lower during the warmer months.

But this chilling northeast wind is a distinct phenomenon even when hundreds of miles intervene between the locality where it blows and the coast, and the writer has observed it in all its keenness and sense of penetrating, chilling humidity, with a misty scud, and a permanence for many hours, *when the northeast horizon was seen to be clear.* This was in the elevated plateau of southwestern New York, thirteen hundred feet above the sea, and over five hundred miles from the coast of New England. Fair weather was prevailing at the time at one hundred and fifty miles distance northeastward.

The humid but usually warm southeast wind is equally a general phenomenon, incident to the superior one before named, and belonging to the whole area. It rarely or never comes from the sea at the southeast.

The southwest wind is more nearly a representation of general or continuous movements, and it belongs to the seasons or periods when the temperature is generally increasing over the whole area. It is usually humid, yet elastic, and with an *increasing* capacity for moisture, in this respect reversing the conditions of the two before named. It is the soft, pleasant, peculiarly American wind; with a finely variable force. Rains are frequent with it, and often form in its volume in the warmer months as thunder showers. In the intervals of these there is no local condensation and no scud formed; though in winter and the cool months low clouds are formed in a southwest wind during continued storms.

This southwest wind becomes more southerly at the Mississippi River and westward, and it is there relatively higher in temperature, though with no greater distinction from the general character it has as a leading feature of the sensible climate for a very large area.

The great range of extremes has been mentioned as one of the leading general features of the climate of the Eastern United States;—the oscillations of temperature, atmospheric weight on the barometer,

humidity, quantity of rain, wind, &c., passing through larger measures than in Europe or on the west coast as a constant and regular order of things. The existing accumulation of records affords ample proof of this in striking and memorable instances, not less than in the frequent recurrence of these which every one will recall. In connection with various parts of the work, and particularly in the comparison of this part of the continent with Europe, these extremes are freely cited, yet that place scarcely affords the opportunity to do so as fully as is desirable for all purposes, and for this reason several citations will be made in conclusion of this chapter.

The leading element about which all others are arranged is temperature, and the low temperature extremes have the greatest importance, because of their relation to cultivation, and especially to American staples. The range below the mean in temperature is also greater here than the range above it; the depressions are more abrupt and extreme than the points of maximum rise. Plotting the line of temperature for a year the minima are fewer in number, but of greater measures of departure from the mean line; and this is the case at all seasons, and it forms a point of some speculative interest in regard to the principles which control it. At certain times the refrigerating agencies become cumulative in a certain sense, and to witness the extreme attained in these cases suggests doubts of the possibility of restoring the equilibrium. How this is restored over an immense area of country, such as is sometimes affected by extreme refrigeration in the interior, and away from superficial sources of heat, is yet a problem of sufficient difficulty. In February, 1835, nearly the whole area of the Eastern United States was swept by a simultaneous refrigeration, reducing the temperature on an average fifty degrees below the mean for that month—in Maine nearly 65°; in New York 55° to 60°; at Washington 53°; At Augusta, Georgia, 62°; in Northern Florida, 65°, and at Key West 25°. Numbers so large could not be obtained at the several points for any month in any known extremes of heat, as may readily be seen, nor has any instance occurred in which the greatest increase, whatever it was, has been so nearly simultaneous, or over so large an area. Such instances are inexplicable in our present knowledge of the distribution of heat, and they form a remarkable characteristic of this symmetrical area east of the Rocky Mountains. They are evidently derived from exterior sources, though we are yet unable to indicate what these sources are.

The depressions of temperature which are subsequently cited, it is easily seen, are irregular in position and in duration, and when severe they occupy a large area. The winter depressions are greatest in the Southern States, as if, when such a fall of temperature occurs, there

was in that part of the country a higher point from which the fall would commence, and when the refrigeration is complete a more uniform result than before. This is frequently illustrated in localities of contrasted elevation, where the lower point, at first much warmer, becomes at the greatest refrigeration much colder. The thermometer falls no lower on the White Mountains in these winter extremes than in the valleys adjacent; hills in any part of the country which are ordinarily ten degrees colder than a river valley near them, become actually warmer at these extremes. At Washington in the severest cold of 1835 and 1856 a difference of altitude of 110 feet gave large differences in temperature; two positions thus carefully observed differed 14° in January 1836, and 9° in February 1856, the lowest points being respectively —18½° and —21°. This is so common in regard to mere localities as to be well known, yet its application has not been made to the great instances of refrigeration in which the plain of the St. Lawrence, the plateaus of the northeastern States with the interior river valleys, the plains west of Chicago, and again in Western Iowa, may be reduced to the freezing point of mercury. In all these cases a valley or plain in a low local position exhibits the extreme effect, and when these extremes strike over great areas farther south they seem but to illustrate the same principle on a large scale.

At St. Louis, Cincinnati, and Washington, the minimum may be 20° below zero, and the mean of the month may fall 15° below the average. At Fort Gibson, Huntsville, Ala., Athens, Ga., Greenville, S. C., and Richmond, Va., the minimum may be 10° below zero, with the mean of the month 17° below the average. At Natchez, Erie, Ala., the vicinity of Charleston, Fayetteville, N. C., and Norfolk, it may fall to zero. At the 30th parallel these great oscillations may reduce the temperature to a point but 10° above zero in any winter month, and reduce the mean by at least 12°; in the west of Texas this limit in latitude falls off southward to the 24th parallel on the Rio Grande. The extremes here indicated are rare, and they may not occur more than twice or three times in a century, yet they are within the probabilities of the climate in the same absolutely non-periodic manner which belongs to all these changes.

The peculiar range and the position of the single extremes of refrigeration felt as frosts in the months of spring and autumn, form a part of the illustration just given, and exhibit the same laws. They are equally sudden, and apparently from a superior source, as though dropped from the atmosphere without being transferred from a distant point. Like the first they fall lower, relatively, as the measure of heat is greater; they strike at the south when they are unknown at the north; and they affect large areas symmetrically. In the months

affected by white frosts the cold extremes are of less duration than in the winter, and they differ in this respect alone, apparently. A few instances may be cited in proof of the views here stated, beginning with the most recent, and those occurring at the moment of writing.

On Wednesday morning, Sept. 24th, 1856, "a heavy frost" occurred at Columbia, South Carolina, doing great injury to the cotton crop. On the following morning it was felt at Washington, and in neither case farther north. On September 9th there was frost at Rochester, N. Y.; on Sept. 1st and 2d severe frost on various parts of the plain of western New York east of Buffalo; on August 6th a severe frost, killing the leaves of corn, occurred in Michigan near its southern border, and equidistant from the lakes at the east and west. In each case the district influenced was unconnected with any similar one at the north or west, or was not one prolonged from either of those points. In each case so far as known it has been *warmer at the west and north* at the time these extremes have occurred, thus precluding the idea that they are brought from colder districts, or colder surfaces.

The list for every year would be a repetition of similar results; they appear in Wisconsin when unknown in Minnesota; in Michigan when unknown in Wisconsin; and so in New York, Virginia, and Georgia. They are evidently oscillations dependent on the changes of the atmospheric volume in any part of the country by which rain is precipitated,—masses of cold air thrown down, and local radiation intensified at the time. The period of low temperature in which they occur may be instituted by general exterior causes as the cold periods of winter evidently are, but the single sharp reductions are incidents of the more general changes rather than original phenomena.

Instances of this sort may be cited at any length with the same general result of distributing these phenomena of refrigeration of whatever duration—either as single frosts of a few hours of cold, or as reduced mean temperatures for a period of three months—over this great area in the manner which has been defined. They occur as oscillations having a wide range, though falling lower than the measure of this rise above the average. They are constantly recurring in the colder months, and almost constantly during all the year in the northern districts. They are exterior to the surface also, so far as movement is concerned, and they appear to come with some superior movement. It may be a difficult solution, in the present state of our knowledge respecting the condition of the atmospheric circulation, and its power to convey heat or to bring a refrigerated volume, to show how an area like that of the southern half of the United States east of the Rocky Mountains may lose fifteen degrees from its average of heat for a month, and fifty degrees from its average for any period

of twelve hours, when the area north of the 45th parallel has no such loss of heat,—perhaps has an accession of more or less, as in one case a very large increase of heat belonged to the latitudes of Labrador, the winter of 1780. In three out of four cases of refrigeration at the border of the Gulf of Mexico there is no transfer of the cold from the north; if north winds attend it they are not likely to be known in the direction from which they seem to come, or at the extreme of that point. In many cases west winds following a general rain have a deflection from a northerly point, and prevail over a large area nearly at once, but instead of being so swept over the country from the extreme point they are only successively renewed, as incidents of other conditions and changes.

It is clearly to be inferred that the extreme changes of temperature are derived from some causes outside the belt where they are felt, because these changes precede others which might be supposed to originate them. We say the warm weather brings on rain, and the rain brings cold weather, and this may be true to a certain extent; yet great changes of temperature occur with no phenomena of precipitation attending them. A period of excessive heat occurs which is brought to us from no latitude or surface, and which can only come with a superior atmospheric circulation. Changes of a moderate degree would naturally occur in any condition like this from local causes, but we can give no reason why a month or three months together should have an excess of eight or ten degrees of heat above the average, or why a like period should have a like deficiency, derived from local or superficial causes. The wind from the south does not blow long enough to cause such an excess of heat, and it often occurs with little or no south wind. When cold the north wind does not bring it, and often the adjacent areas at the north have a reverse extreme, as in 1780 and 1856. It may not be true that these extremes are always bounded by the recognized limits of the temperate latitudes, and in some cases we know they are not; but usually the belt of constant oscillation is the belt of the temperate latitudes, or that of medium temperatures rather, since when the heat of the southern United States becomes tropical, as in summer, there are few of these changes; and when the Canadas and Labrador have arctic temperatures, as in winter, the oscillations are rare there also, or wholly cease.

With the changes of temperature all other changes are directly associated, and particularly those of the quantity of rain. This may be a primary condition, or one deriving its extremes from some existing source in a great degree, since the supply of moisture to all continental areas necessarily comes from an exterior source of some sort. It here clearly comes from a superior atmospheric circulation mainly,

and that circulation brings an irregular or variable supply—variable as regards the simple succession of periods, though not subject to permanent change toward a greater or less supply. This principle lies at the basis of most of the variations of dry and wet seasons, and, in addition to the temperature, it exerts a large influence in promoting irregularity, or in causing evaporation or precipitation which would not occur in the regular order of the conditions without these irregular changes.

It would be of almost equal interest and pertinence to the citation of extremes of cold just made, to cite the instances of excessive drought in the history of the United States in illustration of this part of the subject, but their history is much more difficult to establish. The extremes of absence of humidity occur irregularly at all seasons, but they are most sensible in summer because they are then of great practical importance. This importance is increased by independent circumstances of heat also, so that the positive measure of the condition is difficult to define. There is no measure more simple and accurate than that of the quantity of rain which falls, yet this may very incorrectly represent the atmospheric humidity, since at a high temperature a great quantity remains suspended in the air when no rain falls for a long period. Nor does any measurement of the humidity of the mass of air at the surface represent the condition of the air as a whole correctly—the suspended moisture of the atmosphere is always irregularly diffused, and the various strata may differ very widely in their hygrometric condition. At a time of high temperature the surface stratum of air may be very dry, while nearly saturated strata of great volume exist at the usual limit of cloud formation. This is not only often the case when no rain whatever falls, but also during moderate rains, and especially for a short time preceding rains. In cold or cool weather it is an equally frequent condition of the surface air to be at or near saturation while the upper volumes are almost destitute of moisture, and when no considerable precipitation does or can take place. In the greater part of the time designated as winter months in the United States the upper atmospheric volumes are at intervals extremely dry, and saturated only when invaded by volumes of a comparatively high temperature. The process of condensation is then nearly constant at the surface, and low clouds with much sensible humidity prevail.

For these reasons the enumeration of periods of actual deficiency of rain, is less directly expressive of the primary general conditions of the climate, than the citation of extremes of temperature. If traced accurately in regard to actual deficiency, we have not a positive measure of the deficiency of moisture, and have only a subordinate result for philosophical purposes. The practical purpose may be served to

some extent by the general facts however, and with a brief reference to these the subject may be concluded.

In another place the range of the quantities of water falling, is given in general terms as about two and a half times the least observed quantity, in the yearly summaries for the Central States—it may fall to less than half the average, and rise to a quantity nearly double that average. There is here a singular coincidence with the temperature range in the relatively greater depression of the minimum, and the less elevation of the maximum; no maximum extreme departing so far from the mean line as the minimum extreme does.

In ten years, 1797 to 1807, observed by the Medical Society at Charleston, S. C., there were four separate months absolutely without rain; in Jan. 1751, as observed by Dr. Chalmers, there was none—in a period of thirty-two years of the early records at Charleston—Dr. Lining from 1738 to 1752, Dr. Chalmers from 1750 to 1759, and the Medical Society from 1797 to 1807—the greatest quantity of rain in the year was 83.4 inches in 1799, and the least 36 inches in 1742; the average being 48 inches. The less accurate military record at Fort Moultrie gives the minimum quantity of 35.8 inches for 1850; one month in 1843, in the series of twelve years from 1843 to 1854, being wholly without rain. In a series of 18 years at Savannah Georgia, closing with 1854, the minimum for the year was less than 28 inches in 1839, and the maximum 70 inches in 1848; the mean being also 48 inches. At Norfolk the military record for 19 years previous to 1855 gives the minimum at 20 inches in 1854, and the maximum at 74 inches in 1840; the mean being above 46 inches. This last record has some evidences of inaccuracy, but grouping the results at these three posts on the most humid portion of the Atlantic coast we have the least quantity at half the average, and the greatest at one and a half times that average, in the summaries for the year; the months of least quantity have none, and the greatest monthly quantity is 18 inches at Norfolk, 15.8 at Charleston, and 20.4 at Savannah. At St. Johns, Berkeley Parish, near Charleston, the least quantity for a year in a period of ten years ending with 1855 was 24.9 inches, in 1849; confirming the view that the minimum quantity on the sea-board of the Southern States may fall nearly to half the annual average.

Along the Gulf Coast the range is much less, and the minima do not fall so low, though both the conditions and the records are irregular. The great droughts of the inland belt from Texas to the Carolinas do not affect the coast at New Orleans and Mobile in any serious degree; they are more likely to be felt at the west of Texas as in the present summer, 1856, or in Florida. In 1854 the widest and most general drought for many years prevailed in all the central States from

Upper Texas to Virginia, and in all these the quantity of rain for the year was not more than two-thirds of the average, and in some places not more than half. For the summer, which is the period of greatest importance in the supply of rain, the deficiency was greater than in any other recent case; and the extent of the district affected requires a tabular arrangement for comparison.

Comparison of the quantity of water falling in rain in the summer of 1854 *with the average quantity.*

	Summer of 1854. *Inches.*	Av. for Summer. *Inches.*		Summer of 1854. *Inches.*	Av. for Summer. *Inches.*
New Orleans . .	10.5	16.5	Pittsburg . . .	4.7	9.9
Brownsville, Lower Tex.	16.9	9.3	Gettysburg, Pa. .	5.3	10.2
Fort Washita . .	11.2	11.3	Washington . .	4.8	12.0
Fort Arbuckle . .	6.5	9.0	New York . . .	5.1	11.5
Fort Smith, Ark. .	4.0	13.9	Burlington, Vt. . .	5.1	10.8
Fort Gibson . .	3.4	9.7	New Bedford, Mass. .	9.5	9.2
St. Louis . . .	5.4	14.0	Norfolk . . .	3.5	15.1
Ft. Leavenworth .	5.7	12.2	Charleston . .	13.7	17.5
Ft. Kearney . .	10.1	12.0	Mobile . . .	15.3	18.8
Ft. Snelling . .	9.0	10.9	Ft. Brooke, Tampa, .	36.2	28.2
Cincinnati . .	10.1	13.7			

These statistics express the actual condition quite imperfectly, yet some exterior results may be distinguished as they stand here. This great deficiency was limited to the central area;—in Lower Texas, on the plains at Fort Kearny, at New Bedford, &c., the drought is seen to be distinctly bounded. Along the gulf coast and in Ohio the apparent sufficiency was not real, and for some portion of the summer and autumn the drought was severe. It was also continued through the following autumn and winter at the south, and for some districts through same months of 1855—the year from June 1854 to May 1855 constituting a period of continued deficiency, which would have given much less than half the average for a year so dated; the last 6 months of 1854 gave but one-third the average at Fort Gibson.

In this case the same general features of distribution appeared,—the phenomenon moved from no point, and in districts beyond its limits at the south and west there was an excess of rain through all these dry months; in Florida, at the latitude of Tampa Bay, the quantity of rain was much above the average. As one of the most widely extended droughts known to the climate it had some greater resemblance to the cold extremes than these droughts ordinarily have, and its origin and causes cannot have been less remote and less decidedly exterior to the surface of the area affected, than in those cases of prolonged cold.

NOTICES OF THE PRINCIPAL INSTANCES OF GENERAL AND SEVERE DEPRESSION OF TEMPERATURE CHARACTERISTIC OF THE UNITED STATES.

The range of temperature in non-periodic extremes is characteristic of the climate, and though no part of the temperate latitudes is free from them, they here fall lower, and change in a more nearly constant succession. A summary of the principal instances of this depression may be given here more conveniently than elsewhere, perhaps.

Within the limit of historical notice, but previous to the commencement of thermometric records, there are two or three conspicuous instances of great reduction of temperature in the winter months. The somewhat vague statements we have of these at least suffice to show that the general condition was then the same as now. In 1717 the "Great Snow" occurred, which is often mentioned in New England history of that date. It continued for several days, Feb. 19th to 24th, and remained five or six feet deep on a level at Boston, and over all the settled parts of New England. "It continued so long and severe that multitudes of all sorts of creatures perished in the drifts. We lost at the Island (Fisher's Island, L. I. Sound) and farms eleven hundred sheep, besides some cattle and horses interred in the snow."* This winter is the most conspicuous, if not the only one noted for extreme cold for a long period previous to 1740.

The winter of 1740–41 was distinguished both in the United States and Europe for intense cold. Jefferson speaks of it as having been in Virginia only less severe than that of 1779–80; it was "commonly called the cold winter," and was noted in Virginian history for extreme severity. Dr. Lining made observations at Charleston, S. C. for December 1740, and this is the coldest month in his series of 15 years; 1741 was not given in his published records. Dr. Noah Webster says the winter of 1741 was one of great severity, and equal to that of 1780. The *Boston News Letter* of Mch. 5, 1771, says: "We hear from Stratford, Conn., that the Sound is frozen over three leagues across, so that people ride every day thence to Long Island." In a subsequent number a certificate of several persons appears, testifying that they had crossed the Connecticut river on the ice, and with horses, at the 1st of April.

This is the same winter with that alluded to in various places as one of intense severity in England, when the Thames was frozen over, and much suffering ensued; though that is often named as "the winter of 1740." (Ph. Trans. 1781.) It was one of peculiarly American characteristics, however, for all the area of the United States then known.

The next citations are mainly at the south, and the cold is defined by the measure of injury to tropical fruits. Gayarre cites one at New Orleans in 1748;—that of 1765–66 was "one of the four winters in a century in which the Hudson river was frozen over at Paulus Hook;"—Bartram mentions that of 1766 in Florida; and Forbes (Sketches of Fla.) says of the last, "on January 3d, 1766, frost destroyed all the tropical fruits except oranges" in northern Florida; and Bartram gives 26° as the lowest temperature observed by him at that time on the St. John's river. In this winter the olive trees were generally killed along the Rhone in France. (Rozier's Cours de Agriculture.) Gayarre cites another severe winter in Louisiana in 1768, and still another

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* John Winthrop, of New London, Ct., in a letter to Dr. C. Mather, Sept. 12, 1717; in Hist. Coll. vol. ii. p. 13. Dr. Harris mentions it in "Chronological and Topographical Account of Dorchester;" In Dr. Holmes' "History of Cambridge" this winter is named as "memorable for the great snow." At a public funeral at Cambridge ministers and magistrates were detained several days by impassable roads.

in 1772. (Hist. La.) How general these were cannot now be ascertained, though at the localities named they were very severe, as the destruction of oranges and other tropical trees proves.

In 1780 the most signal and severe depression of temperature occurred belonging to our entire history, except, perhaps, that of 1856. Jefferson (Notes on Virginia) says that "in 1780 the Chesapeake Bay was frozen solid from its head to the mouth of the Potomac. At Annapolis the ice was five to seven inches in thickness quite across, five and a half miles, so that loaded carriages went over it." "York River was frozen over (at Williamsburg, Va.,) so that people walked across it,"—the lowest temperature observed there was 6°. Webster remarks an immense snow fall in New England; "for six weeks no snow melted. The sound was entirely covered with ice between Long Island and the main, and between New York and Staten Island." Troops crossed from New Jersey to Staten Island to attack the British forces on that island,—Washington "supposed that an attack on about 1200 British troops posted on Staten Island might be advantageously made, especially in its present state of union with the continent by an unbroken body of solid ice," (Ramsay's Washington.) The crossings to and from the island were effected on the ice.* "In the winter of 1779-80 Bayou St. John (New Orleans) was frozen for a considerable time, a phenomenon that did not occur again until December 1814"—(Darby.)

"The Delaware River was closed from the first of December to the 14th of March; the ice being two to three feet thick. During the month of January the mercury was several times at 10° to 15° below zero, and only once during the month did it rise to 32°. Long Island Sound and the Chesapeake were so completely ice-bound as to be passable only with horses and sleighs," (*Peirce*, from old records.) Dr. Webster gives the following thermometrical observations at Hartford, the days on which the temperature was below zero only are copied.

HARTFORD, CONN.

Jan. 2d,	1780 . .	— 7°	(at sunrise).
" 8th,	" . .	— 1	"
" 19th,	" . .	—13	"
" 21st,	" . .	— 6	"
" 23d,	" . .	— 9	"
" 25th,	" . .	—16	"
" 26th,	" . .	— 6	"
" 27th,	" . .	— 2	"
" 28th,	" . .	— 8	"
" 29th,	" . .	—20	"
" 30th,	" . .	+15	"
" 31st,	" . .	— 4	"
Feb. 3d,	" . .	0	"
" 5th,	" . .	— 8	"

GLASGOW, SCOTLAND. (*Phil. Trans.*, 1781.)

Jan. 13th,	1780 . .	—13°	(6 a. m., on snow)	0° in air.
" 13th,	" . .	—18	(11 p. m., ")	— 8 "
" 14th,	" . .	—22	(6 a. m., ")	—14 "
" 22d,	" . .	— 3	(6 a. m., ")	+ 5 "

At Lyndon, in Rutland, England, Barker (Ibid.) says: "The year began with frost, and was, perhaps, the severest winter since 1740. The frost was not so steady as in 1840, but very sharp, and the ice not entirely gone for nine weeks, from December 22d to near the end of February."

At Williamsburg, Virginia, the thermometer was nearly at zero, and from all the notices accessible we cannot doubt that the average depression of temperature in the Eastern United States was more than 50° from the mean, and this was at several intervals in a period of some weeks in which the depression was always great. It was singularly severe in the British Islands also; in both the extreme cases, 1740-41, and 1779-80, those islands participating quite fully in the conditions prevailing here. But in the last case, 1780, the northern areas of this continent had a reverse extreme, and were as much warmer than usual as the districts here were colder. At two stations then observed in Labrador, the Missionary La Trobe found the lowest temperatures at very nearly the measure of those recorded at Hartford, Connecticut. In January and

* In *Hugh Gaines' Diary*, kept in New York during the revolution, occurs the following entry "1780; Sunday February 6th;—This day eighty-six sleighs went to Staten Island on the ice with provisions for the troops."—(Collections of Col. Force.)

February 1780 the lowest readings were —16° and —23° at Nain, and —13° and —17° at Okak; the places being at 57° and 58° of latitude. The monthly means were also fully equal to those observed at Hartford, and for January they were 26°.5 *warmer than the average of the two preceding years.* Though nominally in the temperate latitudes this part of Labrador is really in the Arctic climates, and it can rarely be brought into comparison with the United States for want of observations. Beyond Quebec the temperature depressions which have so large a range and measure here appear very rarely if at all, and in at least two conspicuous cases the conditions prevailing here are reversed, and great excess of heat exists there simultaneously with the most intense refrigeration here.

The winter of 1783 was severe at Philadelphia; "The Delaware River closed as early as November 28th, and continued ice-bound until the 18th of March; the mercury was several times below zero." (*Cor. Phil. Inq.*) The lowest temperatures noticed at Philadelphia were —12°. Dr. Noah Webster gives some extreme readiugs of the thermometer in 1784, which appear to belong to this winter recorded as severe at Philadelphia; and it should, probably, be designated that of 1783–4. The observations were at Hartford, Ct.

Feb. 10th, 1784, lowest temp.	—19°	Feb. 14th, 1784, lowest temp.	—20°
" 11th, " "	—12	" 15th, " "	—12
" 12th, " "	—13	" 16th, " "	—16
" 13th, " "	—19	" 17th, " "	—16

Dr. Webster remarks* "this is the most extraordinary instance of intense cold that I have ever known."

The winter of 1788 was still more severe in Lower Georgia and the south; below Savannah the ground was frozen in January, and ice formed in ditches; the lowest temperatures observed there were 22° in January, and 20° in February of that year.† At Philadelphia "the whole winter was intensely cold; the Delaware was closed from the 26th of December to the 10th of March." At Salem, Mass., it was not particularly severe however, the mean of the first two months being but 2° less than usual, and the lowest single reading —4°. (Dr. Holyoke.)

In 1790 an extreme degree of cold was observed at Quebec, the thermometer remaining at 5° to 33° below zero from Feb. 8th to 13th, (McCord, from Quebec records.) This was less severe than the extreme at Hartford, however.

In 1792 Darby says that the Ohio at Wheeling was frozen for upwards of forty days, so that heavy carriages crossed it, and "the quantity of snow was the greatest known there since 1780."

In 1796–7 the wiuter was severe, all the rivers at the west being frozen up according to Darby and Drake; but in the early months of 1796 the greatest severity of cold was felt there—"In 1796 the Mississippi and Ohio and their confluents were frozen to their junction." (Drake.) Of 1796 Jefferson says, that should he revise the notes on Virginia, he should place the minimum temperature assigned to the eastern portion of that State lower than before, as he had observed it at $1\frac{3}{4}$° above zero, only, on January 31st of that year at Monticello. (Jefferson's works.)

There are several notices of severe cold in 1796 and 1797 which are difficult to place in regard to the months intended, but it appears that the winter of 1796–7 was universally cold. Dr. Wilson observed the thermometer at 17° at Charleston in December;—"the coldest days on record are December 23d and 24th 1796." (Ramsay, vol. ii. p. 52.) In this month the thermometer fell to —14° at Cincinnati, and on January 8th, 1797, to —18°. (Drake.)

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* Quoted in *Am. Almanac*, 1837.

† Holmes, in Mems. Am. Acad., vol. 3. His point of observation was at Midway, 30 miles southwest of Savannah.

In 1800 the severest cold since 1780 was experienced in the Southern States, though it was not unusually cold in Massachusetts. "On January 10th 1800, there fell at Savannah the deepest snow ever known in Georgia. By a letter from Midway, Ga., of 17th February, 1800, I am informed that the snow has been three feet deep in places, and sixteen to eighteen inches deep on a level." Great quantities of sleet fell also. (Holmes, in Mems. Am. Acad.) Snow and hail fell the whole day on January 10th at St. Mary's River, Florida, and on the 11th the snow was five inches deep. The lowest temperatures were, 10th, 37°; 11th, 28°; 12th, 34. (Forbes.) At Natchez the lowest observation was 17° by Gov. Winthrop Sargent's record; and the mean of January was 6°, and Feb. 9°.5 below the average. Near Natchez Mr. Dunbar observed the lowest at 12°, and the means 5°.8 and 9°.3 below the averages for January and February respectively. (American Phil. Trans.)

Darby speaks of the severe storms of sleet and snow in Louisiana in January 1800, a heavy fall of snow occurring at Opelousas, with general and severe injury to tropical fruits and tender growths.

At Quebec the lowest observation recorded in this month was —6°, showing a very high relative temperature. At Salem, Mass., the lowest was —2°, and generally the northern districts were little colder than usual, while some were decidedly warmer.

For a considerable period subsequent to 1800 there are no instances of excessive cold in the winter months; there is no month from 1800 to 1828 at Salem, Mass., in which the mean temperature falls more than a trifle below 20°, and the single readings below zero are so great as 10° only in 1817, 1818, and 1821; 1815 and 1826 being 9° below. But during this period the most remarkable depressions of temperature in the summer months, known to all history of thermometric measurements, occurred in the period from 1811 to 1817. Of these 1812 and 1816 were the coldest, the reduction in both cases being continued over all the months of each year in a greater or less measure, but of no considerable amount in winter. Dr. Holyoke's observations at Salem, with other series in Massachusetts, show the following differences from the mean of a period of years at the several points:

	Salem.			New Bedford.		Williamstown.	Cambridge.	
	1812.	1815.	1816.	1815.	1816.	1816.	1812.	1816.
Jan. . .	—3°.4	—2°.1	—0°.4	—1°.9	—2°.2	—1°.5	—6°.3	+5°.0
Feb. . .	—2.5	—4.3	+0.3	—3.4	+1.6	+4.0	—1.7	—0.6
Mch. . .	—6.0	+0.7	—4.7	+2.3	—1.9	+0.6	—6.7	—4.1
Apl. . .	—2.1	—3.0	—0.7	—1.7	—1.4	+0.7	—2.7	—2.5
May . .	—7.2	—3.3	—3.0	—2.2	—2.5	—1.4	—6.9	—4.5
June . .	—4.7	—0.5	—5.4	—0.3	—5.0	—3.2	—5.0	—6.0
July . .	—4.9	+2.4	—5.7	+1.0	—5.8	—3.8	—2.7	—6.5
Aug. . .	—3.6	—2.8	—1.6	—2.0	—2.2	—2.0	—3.0	—3.2
Sep. . .	—4.5	—3.8	+0.5	—0.5	—3.3	—3.4	—4.7	—4.8
Oct. . .	—0.7	+0.3	—1.6	—0.7	+0.8	+1.4	—2.0	—0.1
Nov. . .	—2.1	+3.9	+1.7	+2.4	+2.6	+0.6	—0.4	+3.5
Dec. . .	—0.4	+1.0	+1.8	—1.7	+2.0	+2.3	—5.0	—2.3
Year . .	—3.5	—1.8	—1.5	—0.7	—1.4	—0.5	—	—

The observations at Cambridge are in an interval following a series by Prof. Farrar, and they may be inaccurate. Each of these shows a great reduction from the average of summer heat particularly, and both 1812 and 1816 were memorable as "cold summers" for all the northern United States. From May to September of 1812 each month was from 3°.6 to 7°.2 below the average, a most unprecedented refrigeration, and equalled for two months only, June and July, of 1816, which were 5° and 5°.8 below. In the northern States snows and frosts occurred in every month of both summers; Indian corn did not ripen, fruits and grains of every sort were greatly reduced in quantity, or wholly cut off. Prof. Dewey, at Williamstown, Mass., remarks that "there was frost in every month of this summer (1816); on June 7th a light snow;

very little Indian corn ripened," (Mems. Am. Acad., vol. iv.)* Frost occurred even at Philadelphia in July, 1816. (Darby, Statistics, &c., of La.)

There are, unfortunately, no records by which the exact condition may be learned in the southern States, but it is believed that the refrigeration was not so great as in the north. In England 1816 was almost as extreme as in the United States, and the effect of the great degree of cold on the productive capacity was quite as great. The observations made by the Royal Society of London show the spring and summer of 1812 to have been 2°.8 and 3°.8 respectively, below the mean; and the like seasons of 1816, 2°.7, and 4°.8 colder than the average. Both were "famine years," the last equally so on the continent in France and Germany, though the Black Sea countries were unusually favored and productive.

From this date to 1830 the cold extremes were less important, though very severe local depressions occurred. In Feb. 1818, various *lauracea*, the sassafras tree and others, were killed by the cold in Ohio. At Marietta the thermometer fell to 20° and 22° below zero; peach trees were killed, and not again until January 1852, and the still more severe cold of 1856, was there similar injury to forest and fruit trees in that State. (Dr. Hildreth, Am. Jour. Sci., 1837, 1852, &c.) The cold of 1818 cannot be compared generally for want of observations.

The winter of 1818-19 was severe in New England, the mean temperature at Salem being 21°.5 for the three months, or 6°.4 below the mean of the winter for 43 years. This is also difficult to trace farther, and it could not have been universally severe. In January, 1820, the mean at Fort Snelling was 0° 9 only, a fraction lower than at any subsequent date to 1856; but no other part of the United States was similarly cold. In the same month of 1821 the temperature was lower than in any other winter month since 1792, and 6°.2 below the average; at New Bedford the mean was 5°.7 below the average, with a single observation at 10° below zero. At New York the winter of 1820-21 was also "one of the four during a century in which the Hudson between Paulus Hook and New York was crossed on the ice." (Caldwell.)

In 1825-6 the winter was cold in New England; the following extremes were observed at the close of January, 1826.

Bath, Me., . . .	Jan. 31,	—24°	Amherst, Mass , . .	Jan. 31,	—24°
Portland, . . .	"	—27	Springfield, " . .	"	—18
Cape Diamond, Quebec,	Feb. 5th,	—40½	Boston, " . .	"	—12
Montreal,	Jan. 31, and Feb. 1st,	—38	New Bedford, " . .	"	— 6
Concord, N. H., "	"	—26	Hartford, Ct., . .	"	—14
Brattleboro', Vt., "	"	—27	Washington, D. C., .	"	0
Salem, Mass., "	"	—17	Natchitoches, La , .	"	14

On Feb. 22d mercury solidified at Plattsburg, N. Y., a condition requiring a reduction to —40½°.

The next severe depression was in the winter of 1830-31, when the greatest refrigeration was at the northwest, the single readings being frequently at 22°, 24°, and 26°

* In Thompson's Hist. Vermont similar facts are stated. "It is universally conceded that the year 1816 was the coldest ever known in Vermont. Snow is said to have fallen and frosts to have occurred at some places in the State in every month of that year. On the 8th of June snow fell in all parts of the State, and upon the high lands and mountains to the depth of five or six inches. It was accompanied by a hard frost, and on the morning of the 9th ice was half an inch thick on shallow standing water, and icicles were to be seen a foot long. The weather continued so cold that several days elapsed before the snow disappeared. Corn and other vegetables were killed to the ground, and upon the high lands the leaves of the trees withered and fell off. Very little Indian corn came to maturity," &c., (p. 20.) "In 1816 snow fell (at Norway, Maine) on the 6th, 7th and 8th of June." (Barton, Am. Alm.)

below zero at the military posts of Wisconsin in each of the three months. In Florida this winter was also severe. The monthly means were 10° below the average in the latitude of St. Louis for Jan. and Feb. 1831, and at New Orleans, Tampa Bay in Florida, &c., 5° below for the same months. Though this is an extreme degree of cold at the south the injury to tropical vegetation was not important.

At the close of 1831 a severe and universal depression of temperature occurred; the month of December was 15° below its average at the northwest, and from St. Louis to New York and Norfolk. At New Orleans it was 9° below; at St. Augustine 5°, and at Tampa Bay 2°.4 below the mean; showing that the depression was central to this part of the continent, diminishing in degree both at the north and south, as in most other severe extremes. Of this winter Dr. Hildreth says: "the Mississippi river was frozen over in December for 130 miles below the mouth of the Ohio, a circumstance before unknown. The river was also covered with floating ice below Natchez, and at New Orleans ice formed strong enough to skate upon." At Fayetteville, Vt., the mean temperature was 8°.3; "colder than any other month in the last half century." (Field.) At Toronto it was the severest month since 1830. (Lefroy.)

In 1835 a destructive severity of cold occurred in the southern States, cutting off tropical fruits which had been uninjured for more than half a century. The following comparisons will show the relation of various districts:

	Single Extremes.			Comparison of Means.		
	Dec.	Jan.	Feb.	Dec.	Jan.	Feb.
Fort Snelling . . .	— 8°	—16°	—30°	+5°.0	+9°.7	—8°.3
Fort Howard . . .	+ 5	— 6	—23	+5.6	+7.1	—8.2
St. Louis	+ 3	+ 9	—25	—3.8	+1 3	—13.5
Fort Gibson	18	14	— 6	—0 2	+2.2	—9.7
New Orleans . . .	34	38	+10	+0.9	—0.4	—9.6
Augusta, Ga. . . .	30	23	— 4	+2.5	—0.8	—11.1
Fort King, Fla. . . .	35	33	+11	+3.1	—1.7	—5 4
Washington . . .	22	—14	— 3	—0.8	—4.0	—7.7
Albany	—10	—32	— 6	—2.7	—3.3	—3.6
Boston	— 6	—15	0	—0.1	+0.4	—0.5
Marietta, Ohio . . .	..	— 2	—15	+ 2.0	+1.6	—9.0
Toronto	..	..	—20	—3 2	+0.6	—9.0

The mean of February was 7°.4 below the mean at Norfolk; 12°.3 at Charleston; and 4°.4 at Key West. The first severe cold was in January at the eastern and northern States;—" when mercury froze at Lebanon, N. Y., the lowest temperature was —20°" at Marietta, Ohio. (Dr. Hildreth)—and though this severe cold at the east extended south to Washington, it did not reach the gulf coast or Mississippi valley. In February the greatest depression was south of the first area and west of it, though it was nearly as low at the east as before. The following table of extremes with their dates is mainly from Niles' Register for April 11th, 1835, and other sources of the same date.

Extreme Temperatures in January and February, 1835.

Bangor, Me.	Jan. 4th	—40°	Providence, R. I.	Jan. 5th	—26°
Bath, "	"	—40	New Lebanon, N. Y.	Jan. 4th	—40
Portland, Me.	"	—21	Albany, "	"	—32
Montpelier, Vt.*	"	—40	Utica, "	"	—34
White River, Vt.	"	—40	Poughkeepsie, "	"	—35
Rutland, "	"	—30	New York, "	"	— 5
Burlington, "	"	—26	Philadelphia, Pa.	Jan. 5th	— 6
Hartford, Ct.	Jan. 5th	—27	Pottsville, "	Jan. 4th	—24
New Haven, Ct.	"	—23	Lancaster, "	"	—22
Franconia, N. H.	Jan. 4th	—40	Hagerstown, Md.	Jan. 5th	—12
Concord, "	"	—35	Baltimore, "	Jan. 4th	—10
Dart. College, N. H.	"	—32	Washington, D. C.	"	—16
Boston, Mass.	"	—15	Alexandria, Va.	"	—16
Salem, "	"	—17	Richmond, "	Feb. 8th	— 6
Pittsfield, Mass.	"	—32	Norfolk, "	"	+ 4
Chicago, Ills.	Feb. 8th	—22	Fayetteville, N. C.	"	— 1
St. Louis, (Dr Engelman,)	"	—25.4	Greenville, S. C.	"	—11
Cincinnati	"	—18	Charleston, "	"	+ 2
Evansville, Ind.	"	—18	Savannah, Ga.	"	+ 3
Lexington, Ky.	"	—20	Athens, "	"	—10½
Nashville, Tenn.	"	—10	Clarksville, Ga.	"	—15
Greenville, "	"	—12	Milledgeville, Ga.	"	— 9
Huntsville, Ala.	"	— 9	Augusta, Ga.	"	— 2
Natchez, Miss.	"	0	Jacksonville, Fla †.	"	+ 8
Baton Rouge, La.	"	+10			

Nearly all the surface of the United States as then observed, or all that East of the great plains, was below zero on February 8th—Natchez at the southwest, and Savannah on the Atlantic coast being the limits, though a large inland area of the north of Florida was also below zero, its limits there being about the 29th parallel. The coldest line was from Fort Snelling southeastward to Savannah, and over all this central area the thermometer was from 50° to 60° below its mean reading. This is the usual position of the greater depressions, and perhaps their extreme measure when so general. In January, a large area of the northeastern States, with a part of New York, was at 40° below zero, the freezing point of mercury, and a depression of 65° from the mean temperature. This depression has occurred but twice, the second time in 1856.

In 1835, a second series of depressions of temperature in the warmer months began, which were nearly as severe as those of 1812 and 1816, the winter months were irregularly severe; the winter of 1835–6 being decidedly so in New England. At Waltham "the thermometer was at or below zero on 26 days." (Fisk.) In many parts of New England snow remained uninterruptedly from December until May, and at Washington City snow lasted two months, a very rare occurrence. In eastern Ohio the cold was severe, and many tropical trees were destroyed in the southwest and at New Orleans.

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* "These temperatures vary little from those observed on December 18th, 1835, and these two are the only instances of temperature so low as —40° known in its history." (Thompson, 1842.)

† Dr. Baldwin, of Jacksonville, gives, in a recent letter to the writer, the temperatures observed at a point five miles above that town, on St. John's river, at this period of extreme cold, by a gentleman residing there as follows:—

	7 A. M.	8 A. M.	9 A. M.	10 A. M.	2 P. M.	6 P. M.	9 P. M.	Day.
Saturday, Feb. 7th, 1835	30°	..	..	..	46°	..	28°	35°
Sunday, Feb. 8th, "	8	12°	14°	20°	44	24°	18	16
Monday, Feb. 9th, "	14	20	24	32	36	..	28	26
Tuesday, Feb. 10th, "	24	33	..	..	58	..	36	36

"Evergreen oaks shed their leaves from this frost, and began to show new leaves again on the 20th of March following. The orange trees were split to the roots, and of course were killed root and all."

(Hildreth.) Long Island Sound was closed by ice, and Boston harbor was nearly closed ; this was considered "next to that of 1779–80 along the Atlantic coast." (Am. Jour. Sci.) The cold was greatest in February, and it was continued through March and April. At Toronto, Captain Lefroy found the six months of winter, 1835–36, the coldest of the period from 1830 to 1854, the mean of this period for 23 years being 29°.9, and that of 1835–6 26°.3. "It is said to have been the most severe in North America since 1779–80." (Can. Jour. Sci., &c.)

The summer months of 1837 had an average depression of 2°.5 for most of the United States at the north and east, but this difference nearly disappeared at the south and west. In both cases the differences were small at St. Johns, Newfoundland, showing that the changes belonged to the continental area, distinctively.

In February, 1838, another characteristic depression of temperature occurred, the mean of the month being 15° below the average at Fort Gibson, 6° below at St. Augustine, 8° at Norfolk, 7° at New York, and 6° at Montreal.

In 1843, an extreme of similar character occurred, except that the low temperature was most decided in March, and more severe relatively. The following comparisons will show the position it had :—

Depression of Temperature in 1843.

	Single Extremes.			Comparison of Means.		
	Jan.	Feb.	Mch.	Jan.	Feb.	Mch.
Fort Kent, Me. . .	—36°	—32°	—11°	+8°.1	—3°.1	+1°.0
Burlington, Vt. . .	—15	—17	..	+8.1	—7.5	—5 2
Toronto	+ 1	—10 2	— 3	+4.4	—8 5	—9.0
Albany (Arsl.) . .	0	—21	— 3	+6.1	—8.5	—8.8
Cambridge, Mass. . .	0	—9	— 7	+4 2	—8.8	—8.3
New Bedford . . .	9	+ 3	+13	+5.9	—6.3	—7.8
New York (Ft. Columb.)	12	9	15	+6.3	—4.8	—8.0
North Salem (near N. Y.)	— 6	— 6	+ 2	+7.0	—5.6	—9.1
Philadelphia . . .	+11	+ 7	+15	+7.1	—2.5	—9.4
Baltimore . . .	10	12	3	+5 5	—6.1	—12 1
Augusta, Ga. . . .	22	18	22	+4.2	—4.0	—12.0
Fort King, Fla. . .	23	18	38*	—2.0	—3.2	— 5.1*
Mobile (Arsl.) . .	26	26	24	+2.1	—3.0	—12.5
New Orleans . . .	29	28	33	+0.2	—4.2	—12.1
Fort Gibson . . .	4	11	10	+3.2	—4.3	—12.7
St. Louis . . .	0	— 2	4	+3.5	—9.6	—16.8
Cincinnati . . .	2	— 2	1	+2.1	—6 8	—14 1
Fort Snelling . . .	—20	—18	—20	+7.0	—15.5	—26.8
Detroit	+ 1	— 6	— 5	+3.4	— 7.4	—13.0

In the chapter on Distribution of Heat, the comparison of the coldest month here, March, is made with March of the previous year, which was very largely above the average temperature. The difference is, in several cases, 35°, a most striking proof of the great range of temperature characteristic of the United States east of the mountains.

"On March 6th it snowed for fifteen hours, and fell to the depth of 15 inches," at Augusta, Ga. (Holbrook.) At several southern and western places of observation, March was the coldest month of the winter. At Augusta, Ga., it was 1°.4 below February, at Mobile 3° below, at New Orleans 2°.1, at Fort Jessup (Natchitoches) 6°.1 below. At this last point it is 17°.8 below the average for March, and the coldest month but one (Dec. 1831) on record at the post for twenty-three years.

The next general and characteristic depression of temperature following this of 1843, was in the winter of 1845–6 ; and as in many other cases it was severest at the south. In Georgia it was considered second only to that of 1855 ; there was snow in Mississippi, and ice in abundance at New Orleans. December was the coldest month, and

* At Ft. Brooke.

the mean was 6° to 10° below the average over the entire coast of the Gulf. It was relatively most severe at points of the coast of Texas. The following representative points may be cited.

	Lowest Observation.	Mean Compared.
Tampa Bay, Fla.	34°	6°.3 below.
St. Augustine, "	23	7.0 "
Pensacola, "	21	10.2 "
N. Orleans, La.	22	10.4 "
Ft. Towson	0	6.8 "
St. Louis	—6	7.8 "
Ft. Snelling	—12	2.8 "
Toronto	—3	5.0 "
New York	12	5.3 "

At other recent dates the refrigeration has been partial, and confined to smaller areas. In January, 1844, a depression occurred at the northeast and in the lake district, but not elsewhere. In the same month of 1847 a like partial cold extreme occurred, falling at the Mississippi and west of it, but not at any part of the country on the east.

In 1849, January and February were quite generally below the average temperature by from 5° to 10° each; though this extreme disappeared at the Gulf coast, where January was three or four degrees in excess at some posts near the 30th parallel. There were some sharp depressions in the central belt from Fort Snelling and St. Louis to New York. The winter of 1851–2 was 3° to 8° below zero for each month in the Eastern States, but not so at the west, where it was on the whole warmer than usual. In the Central and Southern States January was 6° to 10° below the average, with severe effects on the sub-tropical vegetation. The following points are compared for this month.

	Lowest Obs'n.	Mean Com.		Lowest Obs'n.	Mean Com.
Fort Brady	—24°	—5° 5	Charleston	14°	—7°.2
Fort Snelling	—32	—0.5	Norfolk	7	—5.3
St. Louis	—14	—3.6	Washington	—7	—6.2
Ft. Gibson	—4	—5.3	New York	—8	—4.8
New Orleans	17	—8.7	Toronto	—15	—5.9
Pensacola	10	—9.5	Salem, Mass.	—14	—4.5
Key West	49	—5.5	Marietta, Ohio	—23	—8.0

At the east and south this was an extreme instance of refrigeration; the mouth of Susquehanna River was frozen over at Havre de Grace for seven weeks; the Potomac at Washington was frozen over for three weeks; snow fell at New Orleans and remained several days; snow fell also at Matamoras and Tampico, Mexico, on January 14th; and at Charleston, S. C., and Jacksonville, Fla., through the entire day on the 13th. The East River at New York was closed, and crossed on the ice on the 20th, and for three days following. Dr. Hildreth cites temperatures 30° below zero in the Muskingum Valley, with the destruction of native kalmias and rhododendrons, the *pyrus japonica* and other shrubs, in Ohio. Orange-trees were killed at Charleston, and thick ice was formed for several days from 13th to 20th January. This was an eminently characteristic depression for the Eastern States.

In 1854 a similar instance of severe cold occurred, which was more general however, occurring over the interior and Pacific coast, and also in England. At Fort Snelling and the northwest the thermometer fell below the freezing point of mercury, and the mean for the month was 2°.1 below zero at Fort Ripley,* lat. 46° 19′, and 1130 feet above the sea.

* At this post the reporting officer gives the lowest extreme at 50° below zero, and says, "the mercury receded entirely into the bulb of the thermometer, and fifty grains placed in a charcoal cup were completely frozen." Surg. Letherman.

Fort Ripley	—50° (?)	Ft. Defiance, N. Mex.	—20°
Ft. Snelling	—36	Santa Fe	—6
Ft. Brady	—27	San Francisco, Cal.	27
Ft. Kearny	—16	San Diego	31
Ft. Laramie	—21	Ft. Brown, Texas	30
Great Salt Lake	—14 (20th)	New Orleans	25
Ft. Dalles, Oregon	—15	Fort Gibson	1
Puget's Sound	—1	Fort Towson	—3

In England the thermometer fell to 4° below zero at the first of January, and, as in the United States, storms of excessive severity continued for most of the month. It is noticeable that the cold there was nearly simultaneous with that in the United States even to the Pacific coast.

In the first three months of 1856 a still more severe degree of refrigeration occurred, which was central to the middle latitudes of the United States, disappearing at the north at about the 46th parallel. This was a reproduction of the winter of 1780 more nearly than any other, both in degree and in position. The district of the great lakes was but little affected, and the line of greatest severity was at the 35th to the 38th parallels. The tropical coasts of Central America were in some degree influenced, apparently rendering the winter a stormy season instead of one of the usual calmness belonging then to tropical latitudes.* While the middle and lower latitudes of both continents participated in the refrigeration, the higher latitudes of both the north of Canada and Labrador here and the north Baltic countries of Europe, Archangel and the high Atlantic coasts at Norway and the British Islands,—were alike warmer than usual, particularly in December and January.

The following citations will show the measure of depression.

Washington	Jan. 10th,	—10°	Mean of Jan.	11°.5	below	the average.
Philadelphia	" 10th,	— 7	"	10.5	"	"
New York	" 9th,	— 6	"	7.7	"	"
Buffalo	"	— 4	"	9.4	"	"
Pittsburg	"	—18	"	..	"	"
St. Louis	" 9th,	—18	"	14.2	"	"
Chicago	" 10th,	—30	"	..	"	"
Ontonagon, L. Sup.	"	—18	"	..	"	"
Ft. Snelling	" 9th,	—26	"	..	"	"
Ft. Gibson	" 29th,	—15	"	17.8	"	"

The severity of the cold continued nearly three months, and in both the months following the dates given the extremes of temperature fell nearly as low as those cited. Snow remained in large quantity at Washington from the first of January to the middle of March; ice covered the Potomac for the same period; Chesapeake Bay at Annapolis was closed from Jan. 8th to Mch. 14th; the harbors of Baltimore and Philadelphia were closed until late in March; Long Island Sound was closed to navigation from January 25th to February 27th; and the harbor of New York was much obstructed by ice; which several times made temporary communication across the East river. The western rivers were equally obstructed by ice, and it formed in the Mississippi as low as Vicksburg, floating in vast quantities below Natchez. At all points in Louisiana ice formed for weeks, and some places had heavy falls of snow. It was the same through all the States bordering the gulf; and in Lower Texas December gave the greatest depression. An almost simultaneous refrigeration struck over all the United States east of the Rocky Mountains on the 23d and 24th of

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* "From the first of January last we have had very unsettled weather,—heavy rains, much thunder and lightning, heavy gales from the north succeeded by gales from the south;—there has not been such a time within man's memory. We should now be in our dry season, but this day we have had a heavy norther." *Belize Corresp. N. Y. Herald, Mch. 5th,* 1856.

December, giving the sharpest extremes very soon after this date in Texas, and a period prolonged at the north and east as if by continental influences simply.

At the moment of passing these sheets through the press the features of the present winter, 1857, are developed as one of the severest known for the month of January, and with the same general characteristics of maximum severity in the middle latitudes of the United States east of the Rocky Mountains. As in former cases, the Canadas and the Lake Superior region are little affected, the plains of Nebraska and Kansas at the 40th parallel being positively more severe than those at the head of Lake Superior. The signal storms of the eastern States have been most violent at the same middle belt, and the harbors of Baltimore and Philadelphia have been most obstructed, those of New York and Boston next, and that of Halifax not at all.

These citations might be amplified to almost any extent in illustration of interesting leading features of the American climate, and the difficulty is to distinguish the most appropriate mode of introducing these items of observation. But nothing bears so directly on the characteristic distinctions as the illustration of its *symmetry*, and of the *range* of the leading element of heat. Every other condition is similarly marked,—humidity, atmospheric weight, winds, and storms; and the specific attention to this symmetry, which it has been the purpose to ensure by treating it separately, gives a tone to all that belongs to climatology.

IV. GENERAL CHARACTER OF THE INTERIOR AND PACIFIC CLIMATES.

It is proposed to notice the western part of the continent here in the tone which has been followed in the preceding chapter, or in regard to the general distinctions which apply to it as a whole. As such there are some decided features of difference from other districts which could not be disregarded in any notice of its climate, and these belong to almost the entire mass of the continent west of the meridian of 100° west longitude. The exceptions to this uniformity are, first, a part of the great plain at the north which turns westward above the 48th parallel, and lies along the Saskatchawan and other rivers there to 110° and 120° of west longitude, before the limits of the temperate latitudes are passed; and next the narrow coast line north of Monterey of California.

The most expressive designation of the great district remaining, is that applied by Fremont to the Great Basin,—that of *Asiatic* climates; and, though the basins only are fully such, the whole area under consideration is distinguished from other parts of the United States by a greater or less degree of development of these features. The most marked single point is the absence of atmospheric moisture there, or the low measure of humidity, when rain is not actually falling. This arid character begins to be felt at the 95th meridian, and at the 98th or 100th, it causes an abrupt contrast with the country east. The plains have here an elevation of two thousand feet on an average, and from this point they rise rapidly westward at a very uniform grade.

The great prairie region of the Mississippi plain has some features in common, from a point farther west to the woodlands and wooded hills east of the Mississippi, but its peculiarities are of secondary importance. Most of the prairies are as humid as the interior valleys of Virginia at all times, and the greater portion may be much more so in extreme cases. The climatological distinction they have is rather in regard to the sweep and suddenness of the changes which occur, and perhaps in a participation, at times, in the aridity of the desert plains where they border on them. All the plains are prairies

in one sense of the word, however, but that term is here used to distinguish the well grassed, rich, and cultivable plains, where the absence of forests appears to be due to accidental causes only.

With the received ideas of what constitutes a standard of climate —which ideas are mainly taken from Europe, though modified by the condition of the eastern States—we strike upon the deficiency of moisture, and of rain and snow, as the first and greatest distinction recognized in passing beyond the border of the plains. The temperature of evaporation, or that marked by the wet bulb thermometer, is a striking instrumental proof, the difference between this and the temperature of the air often remaining at 20° through many days, or even months, at midday, and the difference sometimes reaching 25° or 30°. At all seasons this difference has a greater measure than is found in the eastern States, and it is remarked by all who traverse the country. Sensible perspiration is rarely experienced in even the warm climate of southern New Mexico under the most active physical exertion, and the languor and oppressiveness attending a heat of 90° to 95° in the eastern States is never felt at such temperatures. Air temperatures of 80° and 90° are almost constant in many districts for all the warmer months, and in the lower deserts they rise to 115° and 120°. The frequent examination of this part of our territory by scientific surveying parties, and the occupation of posts in all parts of it for military purposes, have given a fresh and very thorough knowledge of it within a few years, and these points are as well determined for general purposes as if it had been occupied by observatories.

There are many interesting proofs of this aridity encountered by all who traverse the country, one of which is the effect of the dry and rarefied air in resisting putrefaction of animal substances. A hasty preparation of the meat of the buffalo, or other animals, permits it to be carried almost any distance in safety.* At the altitude of four to six thousand feet, an altitude which belongs to most of the interior, there is, of course, an atmosphere greatly rarefied, and the effect of a

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* Capt. Gunnison (Rept. of Pac. R. R. Survey) describes the mode in use for the preservation of meat taken in hunting in Northern New Mexico as follows: "These hunters travel a hundred miles, kill the game and pack it on asses, taking from ten to twelve days to procure the load and four to return to market. They use no salt, and notwithstanding the daily occurrence of showers about the highest peaks of the mountains, the dryness of the atmosphere is such that the meat is well preserved."

Gregg (Commerce of the Prairies, vol. i. p. 96) mentions that "on the Upper Canadian and Cimarron Rivers the extraordinary purity of the atmosphere is such that the caravans cure meat in the most simple manner; a line is stretched from corner to corner of a wagon body, and strung with slices of beef, which remain from day to day till sufficiently cured to be stacked away. This is done without salt, and yet it rarely putrefies."

moderate surface temperature is to add to the deficiency of sensible moisture by increasing the comparative rarefaction. This deficiency is almost a constant condition, even when rain is falling at intervals, as the rains and their causes are usually local and limited, in distinction from the general rains of the Eastern United States.

The valuable grasses of the country also exhibit the great aridity by drying without loss of their nutritive qualities as the summer advances, and though this is more generally true of the *grama* (*sesleria* or *chondrosium*) in its different varieties, there are many others more or less perfectly preserved by drying as the season advances. A small measure of atmospheric humidity would destroy their nutritive qualities, whether falling in rain or not.

This absence of humidity is very favorable to observation of astronomical and other instruments, and as a remarkable contrast Major Emory makes especial note of the first and only instance of the obscuration of the glass after a storm on the Gila River.* The exception noticed was but an accidental extreme, as the whole remaining distance to the Pacific coast is equally dry with that then passed over.

In a survey from El Paso on the Rio Grande, eastward to the low country of Texas at the 32d parallel, Capt. Pope remarks the first instance of dew as occurring at the eastern border of the Llano Estacado on the 28th of April (1854), and that the first sensible atmospheric humidity in the form of clouds near the surface, or fog, was observed on that and the following day, apparently brought by a southeast wind from the Gulf of Mexico. This interesting border district is unfortunately not sufficiently known to say at what seasons these contrasts are well defined, or whether they are so at certain seasons only.

There are distinguishing conditions of the soil and surface of the whole of the region of basins, and of a large share of the plains and mountains, in what is here designated as the interior and Pacific divisions of the continent, which is believed to be derived from the aridity of the climate. One of these is the great quantity of saline and alkaline elements in the soils or earths of the surface, and this not only in the basins where they might be expected to exist, but on the plains and mountain slopes which receive all the rain falling there,

* On Nov. 8, 1846, after a storm, and on the last mountains passed before reaching the Gila River, Maj. Emory remarks: "For the first time since leaving Pawnee Fork I was interrupted for a moment in my observations by moisture collecting on the glass of my horizon shade, showing a degree of humidity in the atmosphere not before existing. In the States there is scarcely a night in which the moisture will not collect on the glass exposed to the air, sufficient, in two or three minutes, to prevent the perfect transmission of light." Emory's Military Reconnaisance to California, 1846-7.

and send its surplus off to the sea. The circumstances are very clearly stated by Capt. Beckwith* in a resume of the characteristics of the district traversed by the central line of survey for a railroad to the Pacific. Speaking of the plains of Sevier River of the Great Basin he says:

"In these plains, as in all those west from Bent's Fort on the Arkansas to the Basin, and in a few instances in the mountains also, the soil is more or less impregnated with alkali, which is very destructive to vegetation; and salt is often seen efflorescing upon the surface. And as the amount which is annually carried off by lixiviation and drainage, from the very limited amount of snow and rain which is precipitated upon this extensive district in proportion to its area, and from the very great inequality in their distribution over it—as the great body of the rain and snow falls upon the higher peaks and ranges, and is carried down to the main streams through deep cañons and chasms, leaving the plains parched and dry—is constantly renewed from the decomposition of sedimentary rocks, it is impossible to anticipate when the supply will be exhausted. And if the progress of science should develop the means of neutralizing their injurious effects, a material change of climate, providing a greatly increased quantity of aqueous vapor, would be required to bring any considerable extent of this arid territory under cultivation."

The abrasion of rocks and the chemical action, which goes on most rapidly, perhaps, with small or moderate quantities of moisture, appear to accumulate elements unfavorable to vegetation when in excess, and this result of climatological peculiarities evidently grows upon itself. It is not impossible that the supposed or asserted deterioration of the soils of Syria and the interior of Asia may have this explanation, also, but whether so or not we may obtain valuable results by defining this characteristic of our own interior as it actually exists. It commences at the 98th meridian very nearly; the "salt water region" near the Red River of the north being the first point at that latitude. From this point westward along the Missouri saline lakes and marshes and alkaline efflorescences are frequent on the plains both north and south, particularly at the *mauvaises terres* or *bad lands;* which name is applied to many parts of the great area inclosed by the northerly bend of the Missouri, and extending nearly down to the Platte. The distinguishing plant of these soils, the artemisia, begins sparingly at these plains and nearer the mountains it becomes more abundant, covering the arid lands of the basins beyond them with a dense and almost exclusive growth. The immense area occupied by this family of plants, from near the meridian of 100° to the Pacific coast, is noted as an impressive feature of its aspect by Fremont, Beckwith, and others, who have traversed it.

Fremont found the artemisia, or sage, at a point but little beyond the 96th meridian on the Kansas in 1842, and from this meridian to

* Concluding Summary of Central Pacific Railroad Report, 1855, p. 89, octavo.

the Rocky Mountains it constantly increased in abundance. Farther south, plains of salt and gypsum occur between the Arkansas and Canadian rivers at about 97° of longitude, and near the Red River, in Upper Texas, both become very abundant again, occupying most of the country. In Lower Texas at the same meridian they characterize the desert of the Nueces river—thus commencing with great regularity at nearly the same point of longitude for the whole distance, or for nearly twenty-five degrees of latitude. The *cactus* is a characteristic plant of the arid region also, not necessarily associated with saline or alkaline soils, yet not repelled by them. It begins still farther east, marking sandy localities, in some cases, east of the Mississippi. But the larger forms of cactus, and the "interminable sage desert," have their home on the great interior plains and basins, and they are as decisive of the climate in respect to humidity, as the glittering efflorescences which are so conspicuous a phenomenon there.

In many parts of Upper Texas gypsum and the saline earths are as abundant as in the great Basins, notwithstanding a drainage which is sometimes profuse. The southern tributaries of Red River are all bitter or saline waters, and most of its sources are of the same character. Each of the principal rivers southward has at least one saline fork, and after passing round the circuit of those flowing directly to the Gulf, the tributaries of the Rio Grande become still more conspicuously so. The San Pedro and Pecos rivers are always turbid, and bitter, or saline, the last one traversing the whole of the great upper plain, and bearing off solutions constantly renewed by the slightly washed earths of a great dry district.

Many other striking evidences of this preponderating aridity may be given, among which is Fremont's remark on the absence of *mosses* from every point but the very highest, at his crossing from the South Fork of the Platte to Fort Bridger and the Salt Lake in 1843. The characteristic growths of arid regions are mentioned by him in this connection, and the statement that "*cacti have become rare, and mosses begin to dispute the hills with them,*" at the South Pass, is strongly expressive of this general distinction. This is remarked of a point where the rains are at least more equally distributed than in the lower plains and basins, if they are not as equally, in respect to time, as in the eastern United States; and the fact may be cited as a characteristic of the tracts most nearly like the east in the quantity of rain and proportion of humidity, that the cactus and artemisia—the characteristic vegetation of the most arid regions—still remain in small numbers, and that but few deciduous trees, mosses, or growths characteristic of moderately humid climates appear.

The next general peculiarity is the great range of temperature in

the daily changes, or the sudden and local character of these transitions. The heat of mid-day may be at 75 or 80 degrees, yet with the formation of ice, and a temperature of 30 or down to 24 degrees at sunrise; and this is also general over this whole district, and distinct from the extremes occurring at a point in a curve of several days, as in the eastern United States. These last non-periodic variations, so characteristic at the east, are less in the elevated and Pacific districts, apparently, and they are evidently due to causes wholly different from those controlling this sharp curve of variations for the day. The altitude and arid surface both facilitate this daily variation, as the heat accumulates rapidly under the sun's rays during the day, and it is as rapidly radiated at night—the absence of clouds facilitating both processes. With little surface humidity to retard the accumulation of heat from the sun's rays, the mid-day temperature becomes as great as that of districts in the same latitude at sea level; and in summer, when the number of hours of increasing heat considerably exceeds those of radiation, the temperature of plains at five to six thousand feet above the sea becomes equal to that of the same latitudes at points very little elevated near the Atlantic coast. At Fort Laramie the mean temperature of July is 75°, and that of Boston, at the same latitude, 72°.5; that of Rochester is 70°, its latitude being very nearly the same. Santa Fé, at an elevation of nearly 7000 feet has a mean for this month of 75°.3, while Norfolk, at about one degree of latitude farther north, has a mean of 78°. Comparing other points of the Rio Grande valley with the east we find an elevation of 5 or 6000 feet to have temperatures equal to those of like latitudes eastward, and this is particularly the case with the few observations at Great Salt Lake.

At the passage of the Rocky Mountains near the South Pass by Fremont in 1843, five instances occur in July and August, and previous to August 27th, of temperatures at sunrise below 32°, when the mid-day temperatures were from 70 to 83 degrees. At his return passage in 1844, eight instances occur between May 20th and June 20th of temperatures at sunrise below the freezing point, when the mid-day temperatures exceeded 70 degrees. The altitudes in both cases were at or above seven thousand feet, and the average temperature at least as great as that at sea level, for the same dates and the same latitudes. The nights not favorable to radiation gave much higher temperatures. On passing out of the rough mountainous country, between Upper New Mexico and the settlements near Great Salt Lake, Capt. Beckwith remarks the temporarily milder climate, and that

"We had not to record a change of temperature from sunrise to mid-day of from

forty to sixty degrees, to which we have become so much accustomed in these valleys."*

But the low morning temperatures again appeared, and were found to characterize the whole country—the sunrise observations in October for three successive days being at 14 and 15 degrees. In a reconnoissance by Lieut. Mowry at the western border of the basin district of the Columbia river, temperatures at sunrise of 33 to 39 degrees were frequent in August, 1854, and though the altitudes were sometimes over two thousand feet, it is clear that the whole plain of the Columbia, at its lowest points, and to the eastern base of the Cascade Mountains, participates in the great range of daily temperatures peculiar to other portions of this interior region. In the instance last referred to there are observations at mid-day of 90 to 98 degrees.† In the narrative of the Central Pacific Railroad survey by Capt. Beckwith he remarks:

"We observe the greatest contrasts between the heat of the day and of the night in these mountain valleys, from noon to 3 P. M., the thermometer standing at 87° to 92°, and at night falling below the freezing point."—(First report, p. 63.)

These citations might be largely extended to show the peculiarity of great daily range of temperature to belong to the whole interior and arid district, whether greatly elevated or not. In referring to the adaptation of cultivated plants and agricultural staples to this climate these extremes will again be noticed. It may be said here, however, that the effect of extremes in the growth of vegetation is apparently similar to that on animal life, and that the absence of heat may be borne as much more easily in a dry climate than in a humid one as its excess. Col. Emory, in a connection already quoted, remarks that the greater humidity of a night near the Gila made a temperature of 37° more severely felt "than one of 25° in the dry regions."‡

These two great climatological distinctions which mark the interior and Pacific districts control many practical results. They limit the range of many of the characteristic American agricultural staples very much, and, though there are common points of distinction remaining, yet on comparison with the climates of Western Europe the more

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* Survey of Central Railroad route to the Pacific, p. 78. (Octavo.)

† Report of Pacific Railroad surveys, vol. i., (quarto) p. 605, &c.

‡ "At noon the thermometer was 74°, at 6 P. M. 52°, and at 6 o'clock next morning 19°; which has been about the average range of temperature for the last two weeks." (p. 93.) The point thus observed was near the mouth of the Gila, and at the middle of November, 1846. At p. 63, an instance is also remarked of great change of temperature by the nightly radiation. On Oct. 23d, Maj. Emory writes "we retired with the thermometer at 70°, and awakened in the morning shivering, with the thermo meter marking 25°, notwithstanding our blankets were as dry as if we had slept in a house." The camp was near the Mimbres Mountains.

striking points of difference between the Eastern United States and Europe are found to be removed. The semi-tropical features of the Mississippi valley are wanting, and the associated staples, sugar-cane, indigo, cotton, Indian corn, tobacco, rice, and hemp,—are, if not quite cut off, very much restricted on the whole. In the south of New Mexico and California some growth of each of these is possible, the valleys of the Gila and of the southern point of the coast range of California affording favorable localities for their cultivation. Indian corn and tobacco may go much farther, and favorable localities produce corn abundantly in New Mexico and Southern California. But for the remainder of the arid region, or for all that north of the 38th parallel, the cultivation of Indian corn is scarcely relied upon on account of the sharp daily curve of the temperature changes.

These plants of tropical origin, or of range into the tropics, as is each of those just named, have a remarkable tenacity of life and extent of range everywhere on this continent, and they seem to follow high temperatures, under whatever circumstances these occur, more decidedly than any other condition. There are many localities of quite perfect adaptation to the growth of Indian corn scattered over the mountain region, and it is successful at remarkable altitudes in New Mexico,—at the sources of the Canadian and Pecos rivers, on the east, it goes to 6500 feet elevation, and at the Zuñi Mountains, with part of the "Navajo country," near Fort Defiance, on the west, to 6000 and 8000 feet above the sea.

In the foregoing notice of the distinctions belonging to the interior climates, little reference has been made to the absence of general and symmetrical conditions, of change or movement, either in temperature or in what belongs to the dynamics of climate proper, such as prevail in the Eastern United States, yet the localization of all the features of the climate is, from this point of comparison, the leading point of difference after that of the contrast in humidity. Enough of observation has not yet been made to decide what the exact measure of correspondence and symmetry is between different parts of the interior in regard to the greater conditions and changes, but it is probable that some of these outrank the influences which make most of the conditions local. An instance of this greater degree of change occurred in December, 1855, when a sudden and extreme depression of temperature occurred over the whole breadth of the continent below the 40th parallel. This change was felt in California on the 23d of that month, most extremely, and in New Mexico and Texas it also occurred on the 23d, being more severe, however, on the 24th and 25th; and at Washington it began on the 23d and was continued and more severe on subsequent days. In this case but one or two days of difference

existed in the dates of the most abrupt change between San Francisco and Washington, and the period of many days of cold weather which succeeded, was for a time similar over the whole area. Afterward great extremes of cold occurred in the Atlantic States, which were wholly unknown in California, at least.

It cannot now be determined what instances among these changes are of a class not controlled by local influences, but it is certain that there is ordinarily very little correspondence between the conditions in New Mexico and those at Great Salt Lake, California, and Oregon. The general storms characteristic of the Atlantic States are there unknown, though there are great storms and continuous rains, they are of a periodic character along the whole coast. Those of Salt Lake Basin are little known, though it is known that they are not periodic there, nor in the north of New Mexico. The periodic storms of the coast have definite peculiarities quite distinct from those of the Eastern States, apart from the fact they occur in certain months only. They appear to be attended by no phenomena indicating symmetrical relations, as of a disturbance and its removal, with the attendant oscillations of every condition above and below the mean.

Though more extreme in minor conditions, these interior districts are more equable than the east in regard to these greater oscillations, —the changes, of pressure and of temperature, of what may be called the greater non-periodic sort. The barometric range, though not well determined, is there certainly less than in the remarkable fluctuations in the Eastern United States. The free movement of the aerial mass, if that agency can be supposed to affect the result, is interrupted by the frequent ranges of mountains; or rather, the accumulated heat and moisture cannot become so great, perhaps for want of the volume of lower atmosphere, and therefore the disturbance caused by the removal of the excess and the restoration of the equilibrium cannot be great and general as on the great plain of the Mississippi.

The leading distinction of aridity is clearly shown by the charts of distribution of rain, and, though there are exceptions to the rule that atmospheric humidity is fairly indicated by the quantity of rain, they do not apply to any point here except the immediate coast of California. There the low peculiar summer temperature is almost constantly attended by fogs and mists, but there is no parallel to this phenomenon in the interior, or beyond a very narrow line of coast. In the mountainous districts the illustration is, on the other hand, in excess of a fair representation of the humidity, as the rains are local, and profuse while falling, occupying little time or space, and succeeded at once by the otherwise constant aridity of the air.

There is a feature of the temperature distribution that should be

noted here as anomalous, which is the *great excess of heat for the altitudes*, of this district as a whole. It will be seen that the isothermals often continue their direction across the elevated region, without sensibly changing their position in latitude as they approach it from the low plains at the east, or from the ocean on the west. No rule of reduction for altitude is found to apply here in the form given to such rules in Europe, and the entire element of altitude must be excluded from the calculation for many localities, as for the lower valley of the Rio Grande, the Salt Lake Basin, and the plain at Fort Laramie.

This excess of heat, as before intimated, evidently increases the comparative aridity and rarefaction, and it is not only important as a distinct general fact, but also as an agency in modifying other conditions. It is not easy to say whether it is anomalous of itself, or a condition which does not, or which does occur elsewhere on great elevated plateaus; and as it is not necessary here to do more than refer to the fact, which the records abundantly support, we will not undertake any examination of such records as have been made in Asia, and at other elevated plateaus.

In review of the distinctions of a general character belonging to the interior and Pacific climates they may be briefly stated to be *aridity* first; isolation of districts and conditions next; and periodicity of rains, winds and some other prevailing phenomena in distinction from *equally distributed* rains, &c., as in the eastern United States. The *isolation* of phenomena implies an interruption of the symmetry so characteristic of the east, and all the important differences which follow in this train. Extreme contrasts, diversities, and transitions belong here to *place*, or *locality*, and in the east to *time*.

V. COMPARISON OF THE ARID AND INTERIOR AREAS OF THE TWO CONTINENTS.

Little has been known of the interior climates of either continent, from instrumental observation until quite recently, and they have been too much disregarded in the climatological investigations which have been prosecuted for Europe, and based on the positive statistics so abundant there. Little could be done decisively by comparing what was known of them with the accurately observed districts of Europe, and still less could be attempted in a comparison we may now make, to some extent, of areas of like position and like configuration, and with similar climates, on opposite sides of the northern hemisphere. Observations are yet too few to be satisfactory as statistics, it is true, but there are enough, with the fresh and accurate descriptions recently accumulated, to show what the principal points of correspondence are, and to throw great light on both these districts.

The physical geography of some portions of Asia and the east of Europe is still obscure, though Humboldt's travels and descriptions are sufficient for general purposes, and the information they give would have passed into practical use if any occasion for reference to the subject in that manner had existed. But we here occupy a very large area similar to the east of Europe and to Asia, and a comparison of the two is quite necessary to illustrate the capacities of such a district in regard to cultivation and occupation, as well as of great interest in assisting to solve the questions in the complicated and difficult department of climatology. In Asia science has never been applied to practical uses, yet ages of occupation and cultivation have thoroughly tested most points of the capacity of the districts corresponding to our own unoccupied interior; and it would be of great service to obtain all the results to aid us in acclimation and naturalization. Much more may without doubt be done in Tartary, Persia, and other similar districts, to develop the climatological capacity, if the best observations and comparisons were applied to such a purpose; and we may here profit by both the practical knowledge of the old world, and the recent and accurate results of scientific observation.

The corresponding positions in Asia and the east of Europe may be indicated in large divisions, which have a general resemblance. For the Gulf coast of Texas we have there the Mediterranean Sea; for the Gulf coast east of Texas, and the coast of Florida, the Chinese Sea, and the south of China; for the Gulf of California, the Red Sea; for New Mexico, Upper Arabia, Persia, and Caucasus; for Fremont's Great Basin, the basin of the Caspian Sea, and the great interior basins stretching eastward toward Pekin; for British America, the plains of Siberia and of European Russia. This comparison of districts might be greatly extended by applying it to small tracts or localities, and there is so much specific correspondence between Sonora and Palestine, including with the last some portion of the Red Sea coast, as to deserve place in these distinctions.

The great American prairie region is also not difficult to parallel. Immense areas in the south and east of European Russia, and in Moldavia and Wallachia,* with intervals stretching through far toward China indeed, have more or less of the characteristics of the American plains. The immense steppe country of South Russia is often quite as treeless as the American prairie, and as deficient in water; and it has, on the whole, less fertility, and a greater proportion of saline tracts.† In Central Europe the plains are, however, more humid than in the United States, and they increase in humidity rapidly westward. This appears in the number of cloudy and humid days rather than

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* "On the broad level steppes with their luxuriant verdure, taking into view the climate—warm in summer, yet cold and exposed to winds of great severity in winter—it strikes me that there must be no inconsiderable resemblance between this portion of Russia and our own prairies in corresponding latitudes." Randall, *Sheep Husbandry in U. S.*

"The general surface of Moldavia consists of undulating plains of great beauty and of vast extent, covered with luxuriant crops of grass." *Lip. Gaz.*

† In Kupffer's account of the Russian steppes "with geognostical descriptions, made in a journey to the environs of Mt. Elbrouz, in the Caucasus, in 1849, by order of the Emperor," we have the following notes; "Towards the north the chain of the Caucasus descends into the immense steppes which constitute the middle of Russia. From Voronetz to Stavropol we scarcely meet a single hill or tree. Houses become more and more rare, and are collected on a small number of points where the action of some river interrupts the uniformity, and renders more fertile the black soil of the steppe, which is sterile from excess of strength, by diluting it with sand. From Taganrog to Nicolaieff the steppes which border on the Black Sea and Sea of Azoff preserve the same character of uniformity and sterility."

He remarks the excellence of the natural roads when dry; the burnt and yellow aspect of the plains in July, and the advantage of seeing them in the spring before the plants are withered; their great dryness, and great variation of temperature in winter, when, on the great steppes between the Caspian and Aral Seas, the thermometer falls to —13° and —25° with very high winds. *Brewster's Edinb. Journal of Science*, 1831.

in the quantity of rain, but it is still a decided difference. East and south of Kasan they are as dry as at the west of the Mississippi. In Mongolia and Mantchooria the conditions of the dry prairies are probably more closely reproduced than elsewhere, though little is known of that district beyond the fact that there are few or no forests, and many saline and sandy tracts. The great interior basin of the United States has been regarded by Fremont as a distinct climatological and topographical division, but it has a gradual transition, instead of an abrupt one, into every part of the entire district surrounding it. The more precise distinctions which belong to it may be given elsewhere more conveniently, and the special points of comparison between the Gulf coast of Texas and the Mediterranean deserve distinct attention.

The arid climates as a class are new to us, and their peculiarities are not readily understood. It is not easy to divest ourselves of the historic associations which mark them as remote and foreign, and few are conversant with the degree of necessary association, in travel and settlement, which we must at once enter upon with districts as arid and peculiar as Arabia. The arts and the circumstances of eastern life must furnish much which will be required here, and the picturesque symbols and allusions of oriental literature may be recognized in the deserts and mountains of the interior and Pacific districts.

There are some facts in the general comparison of Asia and America which show that surface and configuration do not control climates, even in those arid districts, as decisively as in the middle latitudes of Europe, or in the greater share of the temperate zone. On both continents a desert belt extends, in general terms, from the sea on the west, at 25° to 30° north latitude, northeastward to the centre of the continent, or beyond it. Neither distance from the sea, nor altitude, affects this, and in both cases,—in Sonora and Lower California and at the west of Africa,—the desert comes quite to the sea shore at the west, and lies but little above it. It cannot be said that the immense area of Sahara is made a desert by mountains intervening between it and the sea, and, though the spot similarly influenced is much smaller in America, the analogies are clearly the same in regard to position and climatological effect. These two cases come mainly within the temperate latitudes, and for a belt of perhaps ten degrees of latitude north of the tropic, some exterior and yet undetermined cause controls the distribution of atmospheric humidity and of rain. How far this effect is extended into the interior, where it blends with the recognized continental effect, it is also impossible now to say. The arid regions of the eastern continent are immense, and the whole surface of North America might be disposed along a line drawn northeastward from a point on the west coast of Africa, at 25° north lati-

tude, without doing more than to cover this gigantic belt of sands.* Perhaps the proportion of desert is less in North America, as that of loose sands certainly is, and the actual area is of course but a small fraction of the great measure the desert areas have in the old world. Still the position of the worst tracts on the western coasts, and the evidences of an exterior influence in controlling those of the lower temperate latitudes, is equally apparent, and the same in each case.

It would be of great interest to perfect all these analogies of structure and climatological consequence, but we are not yet ready to do so satisfactorily. The plains are, as before remarked, strikingly similar where cultivable, as well as when they become uncultivable and blend with saline and sandy tracts. The conditions which are apparently controlled by distance from the sea, or by intervening mountains which become the equivalent of distance, are also similar, and we are able in both cases to identify a general cause of aridity which does not originate with either area, and which is clearly exterior to the position, configuration, and every other element of the part of the continent where its effects are felt.

Reference to the statistics and the rain charts will be easy in examination of these positions, and no citation of them is necessary here. The deficiency of rain on this continent is brought out very strikingly by the contrasts of the chart, and it is seen to be much greater than it has been taken to be in former references to the subject.†

The comparison in temperature, also, need not be made more generally than has already been done, or than any reference to the statistics and isothermal charts will do, and the remainder of the comparison

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* "Herodotus described the deserts of Northern Africa, of Yemen, Kerman, &c., and even as far as Moultan, as forming a single connected sea of sand." "The seas of sand may be traced through Africa and Asia, from Cape Blanco to beyond the Indus, or through an extent of 5600 geographical miles." (Aspects of Nature.)

Very little is known of the altitude of the African deserts except that there are no mountains south of the Atlas. South of Algeria barometric measurements show that it is very low,—"by careful barometric measurements Fournel has made it tolerably probable that a part of the northern desert is below the level of the sea." (Ibid.)

† Admiral Smyth, in his work on the Mediterranean, cites a striking instance of the dryness of the Grecian atmosphere: "The air of Attica was always esteemed the purest in Greece and it is still the best; and such is its extreme dryness that Sig. Lusieri, Lord Elgin's artist—whose house was on the site of the Prytaneum—told me that he could leave a sheet of paper on the open ground all night, and write or draw upon it on the following morning. This freedom from atmospheric moisture has, no doubt, greatly contributed to the admirable preservation of the Athenian structures." (p. 270.) The permanence of the adobe or clay buildings of New Mexico and Sonora, a mode of building of the most perishable and fragile character in a climate even moderately humid, is a proof of the aridity of our atmosphere parallel to that named by Admiral Smyth.

may be devoted to citation of details and facts corroborative of the general views. There is a great deficiency in these, however, in the shape most desired, or with bearings readily understood. Few recent travellers have given us notes of the climate of Asia, and many of the notices we have are vague and scattered. Such as they are, some selection from them will be attempted for illustration.

In a "Descriptive and Historical Sketch of Palestine," by Abbe Schwarz, a brief resume is given of the climatological peculiarities of the month, which, as a rough but perhaps expressive outline, may be quoted here. Palestine is the equivalent of Sonora and Lower California in many respects, and it is a natural point of departure in reviewing the interior climate of the old world. The following is a condensation of his statement of the characteristics of the months.

January, (Tebeth);	Very cold, almonds in blossom.
February, (Shebat);	Very cold, with occasional snow and thin ice.
March, (Adar);	Air warmer, with occasional strong wind and much rain, fruit trees in bloom.
April,* (Nisan);	Much rain in the first half; barley ripe at the first of the month; some new wheat; the whole surface covered with flowers.
May, (Iyar);	Rain long ceased, air pure, heat moderate; wheat ripens; apricots gathered at Gaza.
June, (Sivan);	Clear, heat increases; all grain gathered, vey little dew.
July, (Tamuz);	Dew almost ceases; apples, pears, watermelons, and half the grapes ripe.
August, (Ab);	Sometimes cloudy, with much dew; figs, &c., ripe, (tendency toward rainy season.)
September, (Elul);	Less heat, dew abundant "as though it had rained;" grapes, pomegranates, lemons, and quinces, ripe.
October, (Tishry);	Cloudy, heat still high, less dew, some rain; olives and dates ripe.
November, (Marcheshvan);	Many clouds, strong wind and rains; citrons and oranges ripe.
December, (Kisler);	Temperature as in Nov.; sowing grain; although oranges and kindred fruit have been long ripe they continue to mature on the trees till towards April and May."

The same author gives, in addition, some notes in regard to the snows and rains, the locality being at or near Jerusalem. In most years there is no snow, yet it sometimes falls in February and remains several days on the ground. In 1753 an immense quantity of snow is said to have fallen, and the cold was so intense that men perished

* "When I first trod on the sacred soil in the month of Nisan, 5593, (April, 1833) I was not a little surprised to see the whole vegetation of the valley of the Sharon in such a state of forwardness as it is in Germany, whence I came, in July and August." In May "in the district of the Jordan the wheat harvest has long since commenced, while the grain is only half ripe in other parts of Palestine."

near Nazareth. In 1844 a little snow fell on April 11th. A tradition is mentioned that it once "snowed so violently in Sivan (beginning of June) that no one was able to attend the synagogue at Pentecost." An Italian traveller is reported to have found in Upper Galilee a monument with an Arabic inscription; "Be not astonished if snow should fall in Nisan, (April) we have seen it in Sivan." (June.) There are rude and vague notices, but they express some of the prominent features of that climate quite forcibly.

An important division of the rainy season occurs here, which is frequently alluded to by early writers as "the early and the latter rain." The same suspension of rains during a portion of the winter occurs in Lower California* and in Sonora, as well as along the entire coast of the Mediterranean in Europe. It is thus described by Abbe Schwarz:

"In ordinary years the rain begins in October. This so called first rain lasts at times an entire week without interruption, ceases then for a brief space, but occasionally also for several days or even weeks, and commences again; but it is often absent till near Adar (March). Then commences the latter rain, which comes down with great violence and lasts the whole of this month and even a part of April. It has also been known to continue to the middle of June."

Irrigation is necessary in every part of Palestine and Arabia, and, with few exceptions, in the whole of Asia Minor and the arid districts northeastward. Tropical fruits are scarcely more abundant there than in Sonora and Sinaloa, on the west of Mexico, though the difference of latitude in respect to these is perhaps three degrees. Mr. Bartlett observed date trees yet growing at Ures, the capital of Sonora;† and at Hermosilla in the same vicinity, at north latitude 28°, he mentions "beautiful palms," oranges, lemons, figs, citrons, and pomegranates, as being abundant. Over most of this state south of $31\frac{1}{2}°$ of latitude the fruits mentioned frequently occur, and the pomegranates are particularly fine and abundant. This is also a district requiring irrigation.

Points on the lower peninsula of California, particularly Loreto, at nearly 27° of latitude, as described by Mr. Bartlett, strongly resemble the Arabian coasts of the Red Sea. The same intense heat and aridity

* Dr. Gibbons, in some essays on the climate of California published in the California Journals, notices this division of the rainy season at San Francisco as follows:

"There appear to be two rainy seasons rather than one—something like the early and latter rains of Palestine. The one takes place in the latter part of November or December, when the sea winds relinquish their sway, and the other in March when they are about to resume their authority. Between these periods there is an interregnum of dry weather."

† Personal Narrative of Expeditions in Texas, New Mexico, Sonora, &c., by Hon. John Russell Bartlett, 1850 to 1853. Pp. 400—480.

which are known to belong to the Arabian shore of the Red Sea, with extremes of cold in the winter, and with rare instances of rain, are cited by him as belonging to this part of California. The date grows freely at Loreto.

In the modes of retaining water for use there is a striking similarity between the customs, so far as they have been formed, of the occupants of the districts of Sonora and New Mexico and those of Oriental nations, resort being had to *tanks* or *pools* in each case, which are filled at the time of rains, and retain the water in a state of sufficient purity for use until consumed. The oriental mode of constructing tanks on the tops of houses has not been in use in America, so far as known, but the structures of the savage builders in New Mexico and on the Gila, are not wholly dissimilar to those of the east. Small aqueducts called *acequias* are frequently met with at the ruined buildings of the Gila country. The natural tanks of the mountains south of the Gila River are frequently noticed by travellers. They are, apparently, merely accidental displacements of rock, and wholly natural reservoirs, in which the waters of the profuse rains falling at intervals are retained in a state of singular purity through the dry season.*

In the existing notices of the climate of Arabia, Persia, and all of Asia Minor, there is frequent reference to abrupt and extreme changes of temperature, and to severe winter storms; phenomena in which the localized interior features are blended with general ones. Most of the country is elevated, and there are many high interrupted chains of

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* Abbe Schwarz has an interesting description of the pools near Jerusalem, which may here be transcribed. "There are in the Holy City and its environs the following five pools :

I. The Upper Pool, of 2 Kings xviii. 17 ; Isaiah vii. 3, and xxxvi. 2. It is called by the Arabs *Birket Mamuli*. It is about 500 paces from the Kallai, and is about 100 cubits (200 feet) long and broad, and 15 cubits (30 feet) deep.

II. The Lower Pool, of Isaiah xxii. 9 ; also called the Old Pool, likewise the Siloah Pool in Nehemiah iii. 15. It lies in the valley of Ben Hinmon, where the Siloah issues out of the rocky mount, the ancient Ophel, and then falls into the pool, which is considerably smaller than the first. It then comes out again.

III. The Pool of Hezekiah. This was constructed by Hezekiah, and produced by conducting the water into the city. (2 Kings xx. 20.) This pool, which is within the city to the northeast of the Kallai, is of the same size with the Upper Pool, and it is connected with it by means of a canal which supplies it with water.

IV. The pool which lies to the east-northeast of the Bab al Sebat ; which appears, however, to be of modern structure, as no mention is made of it either in the Scriptures or the Talmud.

V. The pool which is to the north of and near the temple mount, and in which, in ancient times, as Josephus reports, the animals destined for sacrifice were washed.

Besides these five there are yet found two ruined pools to the northwest of Mount Zion. . . . Water is found in the first three I have named, the other four are entirely empty, and partly ruinous."—Sketches of Palestine, pp. 271–2.

mountains, which render the local climates severe. Contrasts of both the local and general character strikingly like those of the whole American interior from 30° of latitude northward, belong to the entire area of like position in Asia Minor and south of the Caspian. The transition from localities extremely favorable to tropical fruits, to those so high, cold, and thoroughly desert-like as to preclude almost all cultivation, is more abrupt and extreme than in America, or rather, the localities favorable to tropical fruits intrude farther into the temperate latitudes there.

Murray* gives the following notes of the eastern portion of Persia, where the tropical characteristics are in close proximity to the high table lands which have temperate climates, and the peculiarities belonging to arid and elevated regions.

"The whole of this empire, from the desert of Kerman to the Himalayan Mountains, and from those of the south to the Indian Caucasus, must be included in the transition zone. Between lat. 30° and 33° the flat and low districts enjoy a very hot summer, and a remarkably mild winter. Sometimes in the latter season a thin coating of ice is formed on the surface of still waters and the brink of rivers, but it dissolves at sunrise. Frequently there is a fall of snow in the western districts, but it is never seen at Candahar, (lat. 33°.) In the fertile plains of Moultan, (lat. 30° 50′) shaded by the date, banyan, &c., Elphinstone remarked in Dec., 1809, a temperature of 28° . . . . To the north, Cashmere, (lat. 34° to 35°) inclosed between lofty snow-covered mountains, has a cold winter and a moderately warm summer. The fruits of Europe and the north of Asia Minor are cultivated."

South of the Indian Caucasus are the famous towns of Cabul and Peshawur; these are in narrow valleys, and at Peshawur, lat. 34°, the summers are intensely hot, and it is said that few localities are so favorable to the blending of tropical and temperate productions. The pomegranate, date, orange, &c., mingle with the European fruits. At Cabul the winters are colder, with frequent falls of snow; the summers are also colder, and the tropical fruits disappear.

The central part of this east Persian Empire, lat. 32° to 34°, is said by Murray to be greatly elevated, with summers hardly warmer than those of England, and with winters as subject to frost as those of Norway.

"The snow lies for three or four months; all the rivers are frozen, so that men on horseback and camels loaded with baggage can cross upon the ice. It is said that the plain of Ghazni, lat. 33° 30′, which is a part of the central table land, is the coldest spot in the kingdom."

Of the northwestern provinces to lat. 41°, lying east of the Caspian Sea, and south of the Aral, Murray remarks that

"They present a curious assemblage of plains and mountains, of steppes which are grassy or arid, sandy, sterile, and frequently saline; of bad soil, and of remarkably

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* Encyclopedia of Geography.

fertile land. In the cold seasons the water is all frozen, and caravans cross the river on the ice. The heat of summer compensates the cold of winter, and the former is so intense and prolonged that it dries up all the water-courses."

The correspondence of the interior of the United States, or of the range from Sonora and Lower California to the Great Salt Lake at latitude 41°, is very striking with the conditions just described as belonging to the elevated regions of Upper Persia. Murray mentions the stone pine, and "a cypress of prodigious height," as characteristic forest trees, and these are characteristic of Southern California also. Whether specifically the same with the giant cypress (*Wellingtonea gigantea*) and the large coned pines of the Californian valleys or not, is unimportant to the analogy, or to the similarity of climate they establish. As these Asiatic districts are the native localities of the peach, apricot, fig, and many other fruits and plants of the zone of transition from tropical to temperate climates, we may infer that these will be found greatly successful in the transition district here. Narrow valleys with deserts intervening make up as large a proportion of the surface in Asia as in America, and there is no climatological reason why the Rio Grande, Gila, and Colorado Rivers should not be lined with spots of rich, half-tropical cultivation, like the Tigris and Upper Indus.

The *cactus* in its various forms is a characteristic of the arid climates of North America, and it perhaps indicates some peculiarity not found in similar European and Asiatic districts. Hooker* designates the cactus as "exclusively American," but Murray refers to many instances of its profuse growth in the south of Europe; the cactus *tuna*, or prickly Fig, of which hedges are grown in Spain, and considerable abundance exists in Italy: the cactus *opuntia* in Sicily; and many of the minor species of cactus at various points in the vicinity of the Mediterranean. Notwithstanding the absence of any reference, by Murray and Hooker, to the cactus in Asiatic climates it is believed that they are not entirely absent, and, that, though undoubtedly no prominent feature of the vegetation, they would freely flourish there.† In California, New Mexico, and Sonora, as indeed in all America southward, they form a large and leading division of the vegetable

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* Encyc. Brit.

† Humboldt (Aspects of Nature) speaks of the cacti of the south of Europe as mainly or wholly exotic, and says, "within the last quarter of a century the cactus *opuntia* has extended itself in a remarkable manner into Northern Africa, Syria, Greece, and the whole south of Europe, even penetrating far into the interior of Africa and associating itself with the indigenous plants." He also cites Roxburgh, in the Flora Indica, who mentions two species of cactus as belonging to the southeast of Asia, distinct from the *opuntia*. The euphorbias of Africa are quite similar in their forms and climatological adaptation to the cactus.

growths, and are gigantic on the Gila and Colorado Rivers. The recent American surveys report that the *cereus giganteus* is met with on each of these rivers at some two or three hundred miles from their point of junction, and that at this point, and over a considerable area here, they attain fifty or sixty feet in height in some instances.* A very large number of species, of a great variety of forms, is found distributed over the American interior as characteristic and inseparable forms of its vegetation, and one or two of the smaller species extend over beyond the Mississippi eastward. "Back saw with astonishment *cactus opuntia* covering the shores of Rainy Lake, lat. 48° 40′." (Aspects of Nature.)

What the cause of the non-prevalence of cactacea in the arid climates of the old world may be is not clear, since it does not appear to be climatological. As it is one of the most conspicuous and distinguishing forms in America, a thorough examination of its range in the old world would be well repaid. It is certainly more abundant there than is indicated in Hooker and Murray's notices, who may not have had their attention particularly called to it.

There is another class of plants of universal range in the dry areas of North America, having equal rank with the cactus as a ground of distinction,—the artemisia, or sage of the plains. This is almost universal over the districts of the arid interior, less extreme in that respect than the peculiar field of the cactus; and it begins at the same line from the east, or at the 98th meridian nearly; occupying the northern half as exclusively as the cactus does that of the south. "The interminable sage desert" is the frequent expression of officers in their narratives who have traversed it, and its low, stiff, unyielding form, is often a great annoyance to travellers, as well as the fact of its presence indicating general barrenness for other vegetation, and a deficiency of grass. On the plains of the Upper Missouri, and particularly on an elevated plateau at the head of some of its southern tributaries, Jefferson's and Madison's forks, this artemisia or sage is a leading and almost exclusive form of vegetation. Crossing the ridge of the Rocky Mountains southward from this point, in the direction of Fort Hall, another large and elevated sage desert exists, between the mountains and Snake River. This has an altitude of five thousand feet or more. A large portion of the great plain of the Columbia, which is but 1000 or 1500 feet above the sea, is also occupied by

* Stanly, the artist who accompanied Col. Emory in a military reconnoissance to California has admirably represented the groups of *cereus giganteus*, several of which he asserts attained nearly 60 feet in height. They are frequently mentioned in Col. Emory's narrative as affording subsistence to tribes of Indians. Dr. Bigelow, Botanist to a surveying party in 1853–4, measured one at 45 feet.

the artemisia. Southward to lat. 35° it is the great prevailing form of vegetation, but at this point it is apparently supplanted by the cactus as a distinguishing form. The Great Basin is the central field of the artemisia, and it there becomes larger and more woody than elsewhere. Capt. Beckwith (Pacific Railroad Survey at 41st parallel, 1854,) forcibly refers to its prevalence near Humboldt River:

"The soil of Humboldt River Valley is very light and friable, with extensive districts of sand more or less covered with several varieties of artemisia, which occupies so large a proportion—at least nine-tenths—of our territory between the Rocky and Sierra Nevada mountains, and characterizes its vegetation."

The artemisia may be less directly the expression of a climatological distinction than the cactus, or it may have its place in part from an adaptation to saline and alkaline soils. But these soils are the consequence of aridity of climate, and their characteristic vegetation thus expresses the same result as if directly or solely the representative of atmospheric aridity.

So far as appears from existing works descriptive of Asiatic vegetation, the artemisia is moderately prevalent on the steppes beyond the Caspian, yet nowhere prevailing as an exclusive form. It is scarcely mentioned as existing in Asia Minor or Upper Persia, yet there are cultivated species which probably have their origin there. In this, as in other interesting points where climatological results might be directly applied, the facts are wanting in sufficient abundance to decide the points naturally raised, and the subject can only be opened.

There is a great and almost unknown district in Central Asia, nominally included in the Chinese Empire, though really independent for the most part, usually called Turkestan or Toorkestan. It is a great basin, and variously made up of immense deserts, and of some tracts well adapted to cultivation and grazing. Humboldt, (Aspects of Nature) quotes the determination of Fuss and others who give a mean elevation of 4260 feet for the "so called Desert of Gobi, which consists in part of fine pasture lands." The surface of this desert is said to be not more than 2560 feet above the sea at one point, nearly in lat. 45°, and long. 111° 30′ east. The basin of Kashmir (Cashmere) varies according to the different authorities cited in this connection, from 5000 to 5800 feet above the sea. Thus the northern basin is lower than this of Upper Persia, yet it is still nearly as high as the American interior basin. It is also farther north than this last, yet it is, if correctly described by the notices we have of it, and by its well known commercial products, a climate decidedly milder than that of Fremont's Salt Lake Basin. Humboldt says that

"The neighborhood of Kashgar, Khota, and Yarkand still, as in the time of Marco Polo, pays its tribute in home-grown cotton." In the interior of Asia "the country of

Aksu, south of the Celestial mountains, produces grapes, pomegranates, and numberless other fruits of singular excellence; also cotton (*gossypium religiosum*) which covers the fields like yellow clouds.* In the oasis of Hami (Khamil), two hundred miles east of Aksu, orange trees, pomegranates and the finer vines flourish." (Aspects of Nature).

These localities are in the centre of the Basin, and almost in the centre of Asia, lat. 42½°, and longitude 90° East. The Great Salt Lake of the American basin would not differ greatly in latitude or altitude.†

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* Quoted by Humboldt from a Chinese work. The determinations of altitude were made by the astronomer Fuss, and the botanist Bunge, and are entirely reliable; but Humboldt is of opinion that other portions of this Great Basin are still lower, citing some authorities in support of the view that Lop Nor, the central lake, is but 1400 or 1500 feet above the sea. The growth of fine grapes, oranges, and pomegranates in so high a latitude is thought decisive that it is much lower than formerly and generally thought to be.

† In a recent work, accessible since this chapter was written, there occurs an intelligible and valuable statement of the features and characteristics of this Asiatic Basin region, which may be given here at length, for comparison. It is mainly topographical and general, yet it is from such data alone that the climatology of the region may be inferred in the absence of instrumental observation.

"Between the Celestial Mountains and the Kwanlun range on the southwest, and reaching to the Sialkoi on the northeast, in an oblique direction, lies the great Desert of Gobi or Sha-moh, both words signifying *desert*, or *sandy sea*. The entire length of this waste is more than 1800 miles, and if its limits are extended to the Belur-tag and the Sialkoi at its western and eastern extremity, it will reach 2200 miles; the average breadth is between 350 and 400 miles, subject, however, to great variations. The area within the mountain ranges which define it, is about 1,200,000 square miles, and few of the streams occurring in it find their way to the ocean. The whole of this tract is not a desert, though no part of it can lay claim to more than comparative fertility; and the great altitude of most portions seems to be as much the cause of its sterility as the nature of the soil.

The western portions of Gobi, lying east of the Tsung-ling and north of the Koulkun, between long. 72° and 96° E., and in lat. 36° and 37°, is about 1200 miles in length, and between 300 and 400 across. Along the southern side of the Celestial Mountains extends a strip of arable land from 50 to 80 miles in width, producing grain, pasturage, cotton, &c.; and in which lie nearly all the Mohammedan cities and forts of the *Nan Lu*, or Southern Circuit; as Kashgar, Aksu, Hami, and others. The Tarim, or Yarkand river and its branches flow eastward into Lop-nor, through the best part of this tract from 72° to 86° E.; and along the banks of the Koten River a road runs from Yarkand to that city, and thence to H'lassa; here the desert is comparatively narrow. This part is called *Han hai*, or Mirage Sea, by the Chinese, and it is sometimes known as the desert of Lop-nor. The remainder of this region is an almost unmitigated waste, and north of Koko-nor it assumes its most terrific appearance, being covered with dazzling stones, and rendered insufferably hot by the reflection of the sun's rays from these and numerous mountains of sand, which are said to move like waves of the sea. One Chinese author says 'there is here neither herb, water, man nor smoke;—if there is no smoke there is absolutely nothing.'

Near the meridian of Hami, long. 96° E., the desert is narrowed to 150 miles, and this portion is also less level and more stony, possessing some tracts affording pasturage. A road runs across this narrow part, and travellers find water at various places. It in fact divides Gobi into two parts, the desert of Lopnor and the Ta Gobi, the former

It is evident that the Asiatic climate has much the highest temperature, and that the products in like latitudes could not be made to correspond as regards fruits and cultivated staples. The climate of Utah in lat. 40° will with difficulty produce the peach and Indian corn,—the peach grows only in sheltered cañons at Fort Defiance, lat. 35° 40′—and the basin climate clearly does not permit the growth of cotton and the pomegranate. These only appear at the Gila River, near lat. 33°, or a difference of nearly 10° of latitude in favor of the vast and singular interior basin of Asia. The immense extent of these central plains and basins appears to accumulate the heat, and thus to soften the climate, as the temperature of portions of the interior here is, apparently from this cause, raised above that of the same latitudes at the coasts. As these physical features are on a scale so gigantic in Asia the effect is greater in like proportion: "In summer the heat is excessively great, and in winter there is neither severe cold nor heavy snows." There are no instrumental observations so far in the Asiatic interior, and those at Astrachan, on the Caspian Sea, with those at Pekin, in China, are all that may be taken for comparison with such as we have here. The superior Russian observations in Siberia at Barnaul, Tomsk, Irkutsk, and Nertchinsk, are all on the northern side of great dividing ranges of mountains, and cannot be used as representations of these interior climates. The observations at the stations first named are Russian, however, and to that government belongs the honor of having spread its observatories over nearly half

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being about 4500 feet in elevation, and the eastern not usually rising as high as 4000 feet.

The eastern part, or Great Gobi, stretches from the eastern declivity of the Celestial Mountains in long. 96° to 120° E., and about lat. 40° N., as far as the river Hing-an; and its width between the Altai and the Inshan range varies from 500 to 700 miles. Through the middle of this tract extends the depressed valley properly called *Shamoh;* (*i. e.* sandy floats) from 150 to 200 miles across, and whose lowest depression is from 2600 to 3000 feet above the sea. Sand almost entirely covers the surface of this valley, which is generally level, but sometimes rises into low hills. Such vegetation as occurs is scanty and stunted, affording indifferent pasture, and the water in the numerous streams and lakes is brackish and unpalatable. North and south of the Sha-moh the surface is gravelly and sometimes rocky, the vegetation more vigorous, and in many places it affords good pasturages for the herds of the Kalkas tribes. In those portions bordering on, or included in the Chihli province, among the Tsakhars, agricultural laborers are repaid, and millet, wheat, and barley are produced, though not to a great extent. Trees are met with on the water courses, but they do not form forests. There are no large inland streams in the Gobi north of China, but on its northeastern borders are some large tributaries of the Amoor. On the south of the Sial-koi range the desert lands extend to the 42d parallel.

The general features of this portion of the earth's surface are less forbidding than Sahara, but more so than the steppes of Siberia or the pampas of Buenos Ayres."—*The Chinese Empire and its Inhabitants, by S. Wells Williams, New York*, 1853.

the earth in temperate latitudes, and in quarters otherwise wholly unknown to scientific observation.

Though these statistics are fully given in the general tables, some results may be cited here to facilitate comparison. The higher latitude of Astrachan makes up for its less altitude, and it probably represents the general climate of the great basin eastward very well.

			Spring.	Sum.	Aut.	Wint.	Year.	Diff. of Sum. and Wint.
		° ′	°	°	°	°	°	°
Asiatic.	Lenkoran	Lat. 38 40	56.3	75.7	60.1	40.7	58.2	35.0
	Bakou	" 40 22	54.2	76.5	60.0	40.4	57.8	36.1
	Astrachan	" 46 21	52.2	75.5	51.8	21.1	50.1	54.4
	Barnaul	" 53 20	31.1	63.2	31.5	—0.3	31.4	63.5
	Pekin	" 39 54	55.0	75.8	53.9	28.1	53.2	47.7
American.	Santa Fe	" 35 41	49.7	70.4	50.6	31.6	50.6	38.8
	Great Salt Lake	" 40 46	51.7	75.9	—	32.1	51.0 (?)	43.8
	Fort Laramie	" 42 12	46.8	71.9	50.3	31.1	50.1	40.8
	Fort Benton	" 47 50	49.9	72.8	44.5	25.4	48.2	47.4

The first three Asiatic stations are on the western shore of the Caspian Sea, and nearly at sea level. The American stations are at 2800 to 6900 feet in elevation, so that a direct parallel cannot be drawn. The Asiatic range is, however, clearly the greatest between the extreme seasons, but it is doubtful if the diurnal range is as great as that in the desert districts of the United States. This is an important feature of the climate which it is difficult to illustrate by comparable statistics because the hours of observation are rarely the same, and the absolute maxima and minima still more difficult to attain. This daily range is usually controlled by the conditions of altitude and proximity to mountains, but not always by these, as the great daily range of temperature occurring on the sands of the Sahara shows. The degree of aridity influences it largely, and it would be of great service to know what the actual effects are on the steppes of Asia.

Near the South Pass Fremont observed the formation of ice during almost every night in August. All the officers of surveys have remarked this great daily range as a striking and constant feature, and in this respect there appears to be little difference between the plains of the Columbia, at 1000 feet above the sea, the Salt Lake at 4000, and the Lower Colorado nearly at sea level. The mean daily range for a period of a month at Fort Yuma is from 20 to 30 degrees for the summer months, and this when the mean temperature at 3 P. M. is above 100.° At parts of the greatest elevation, as Forts Defiance, Webster, Union, &c., the range is greater, sometimes attaining 35 degrees. It is still great at Fort Snelling, and at all points on the dry plains, but at New York it is but 10 to 15 degrees. There are

not records enough in the Great Basin to fix the measure of variation there, but it is undoubtedly as great as at the bordering districts mentioned. The constant determined from the Toronto observations by Col. Sabine is at a mean of 15°.7 for the five warmer months, and at 18° for July. The average difference of the extreme hours of these five months at Fort Yuma for three years, and at temperatures excessively high, is 23°.5. Some measures of this range may be convenient in tabular form.

Mean daily range of Temperature for the five warmer months, May to September.

			°
San Francisco,	sea level	. . . 3 years	10.5
Fort Yuma,	"	. . . 3 "	23.4
Fort Defiance,	7200 feet	. . . 3 "	29.5
El Paso (Ft. Fillmore),	3937 "	. . . 3 "	24.6
Fort Union, N. M.	6670 "	. . . 4 "	26.0
Fort Massachusetts,	8365 "	. . . 2 "	28.1
Fort Kearney,	2360 "	. . . 4 "	20.5
Fort Snelling,	820 "	. . . 4 "	18.0
Toronto,	341 "	. . . 12 "	15.7
New York City,	sea level	. . . 4 "	13.4
Pekin, China,	"	. . . 3 "	15.2

Though most of these are derived from the observations taken at the military posts, and sometimes clearly at irregular hours or with defective position of the instrument, it is believed that the resulting averages are substantially correct. At the most elevated interior posts the differences are largest in May and least in August, reversing the order which belongs to eastern districts, and Fort Yuma has the same characteristics also. The following is the comparison for the months, the means being for the periods before named:

	Ft. Yuma.	Ft. Defiance.	Ft. Union.	Ft. Mass.	Toronto.	Pekin.
	°	°	°	°	°	°
May	26.6	32.5	30.1	29.2	15.0	18.7
June	26.8	32.8	28.3	31.1	16.0	17.3
July	21.4	26.7	26.4	29.7	18.0	12.2
August . . .	20.0	24.8	22.9	26.1	16.0	12.6
Sept.	21.7	30.3	24.0	24.2	13.5	15.0

Though the most irregular of these may not be entirely reliable, there is clearly a different relation of the daily changes in successive months in the interior, whether elevated or not, from that belonging to the climate of Toronto and New York.

It is unfortunate that the observations for the interior of the old world are so meagre on this point. There are stations in European Russia and Siberia which might be cited, but their results are quite like those at Pekin, which is also outside the particular class of climates under examination. The analogous effects, as found in the

experience of travellers in daily changes, may be quoted in some instances, however. Humboldt alludes to these in one instance as follows:

"The high temperature of the air which makes the day's march so oppressive, renders the coldness of the nights (of which Denham complained so often in the African Desert, and Sir Alexander Burns in the Asiatic) so much the more striking."

This was in a reference to the deserts in the temperate latitudes of Africa. He adds:

"Melloni ascribes this cold, produced doubtless by radiation from the ground, less to the great purity and serenity of the sky than to the profound calm, and the absence of all movement in the atmosphere at night."

Admiral Smyth remarks that the hot climate of Lower Egypt is marked by cold nights. It is difficult to give citations with satisfactory definiteness in regard to these developments in the climates of Asia, because of the vagueness of the few notices which exist, and of the fact that they are rarely accompanied by thermometrical observations. The great daily range belongs both to the dry and to the elevated conditions, as such, or its cause is equally in each. On the Colorado of California, the Sahara in Algiers, and in Lower Egypt, the range is great, if not equally great with that occurring on high and arid plateaus.

A considerable area bordering the Black Sea on the east and south, differs greatly from other parts of Asia Minor and the Caspian basin in the quantity of rain and degree of atmospheric humidity. All west of the summits of the Caucasian range of mountains, and north of the first principal range in Asia Minor, has this comparatively moist climate, and is covered with heavy forests where not under cultivation.* For whatever reason this condition exists in such abrupt contrast to the saline plains and basins of the opposite sides of these mountain ranges, it is necessary to bear the distinction in mind. The quantity of rain at two points on the eastern shore of the Black Sea, Kutais and Redout-Kale, is near 60 inches annually, and it is still

* "The northern shore of Asia Minor being exceedingly humid, part of the mountain slopes from the edge of the high plains are covered with magnificent forest trees of great variety." (Anatolia, Enc. Brit.) Rev. A. Smith (Am. Jour. Sci. 1846) gives some valuable notices of the climate of the northern part of Asia Minor. He says that the amount of rain, the predominance of moisture and of cloudy weather at Trebizond are striking features, though at Erzeroum irrigation is necessary, and there is no tillable land except at the borders of streams. Of the extremes of cold to which the high interior districts are liable he gives the remarkable proof of a snow storm encountered by himself on the 21st and 22d of June, 1844, at a point but 8 miles from Erzeroum, when the snow fell 6 or 8 inches deep. He cites this as an unprecedented phenomenon according to the popular opinion, yet its concurrence with the statements of Schwarz previously given is worthy of notice.

large at Batoum, Trebizond, and Sinope. The quantity of snow on the west of the Caucasus is very great also, though immediately east of these ranges the whole amount of water falling in rain and snow for the year is but from 15 to 18 inches. The quantity of rain recorded by the Russian station at Lenkoran, nearly at the southern extremity of the Caspian Sea, would, if correct, indicate the existence of a comparatively well watered belt along the mountains passing at the south of that sea and extending eastward to the Indus. The large rivers which, rising here, fall into the Persian Gulf and the interior seas northward are evidence of this, and Murray mentions the existence of heavy forests on the northern slopes of these mountain ranges. The well watered district at the Black Sea and here is extremely limited and local in comparison with the whole, however, and it does not affect the generalizations in regard to the interior which have been given.

In review of the interior climates of the two continents it may be said that they differ only in degree, and though that of the old world has been taken as the arid extreme in contrast with the new, it deserves no such distinction from the point of climate. With larger desert areas than those found here, it necessarily presents greater measures of the peculiarities which belong to them, but this is merely from this fact of disproportion, and not because the continents differ in themselves. The vegetable and animal developments or productions are equally similar in the general sense, and though not specifically the same, they have the same climatological adaptation and requirement.

It has been sometimes claimed that the central continental areas originate the higher developments of both vegetable and animal life, or those which are most valuable in the economy of civilization, at least. The cereals, and the more valuable and varied fruits originate here; and Central Asia, or rather the central areas of the great continent made up of the three in reality, has been regarded as the point of departure for most of the cultivated grains and fruits, the races of domestic animals, the predominating races of men, and the germs of civilization and of letters. These represent the maximum activity of each, and it certainly would seem that climate is at the basis of this activity. The climates which present the greatest curve of changes, both of a constant and of a non-periodic character, within certain limits of temperature, appear to be those most favorable to the activity of all vital forces, or to their activity in certain forms, and such forms as produce concentrated and lasting organisms. Such are the fruits and grains of the temperate and transition zones, and especially of the arid and interior climates of the old world. The analogies of climate certainly show that these may be transplanted to our own interior, and

the absence of any abundance of these in a natural state here, is not conclusive against such an adaptation.

So far as this adaptation has been already tried it is found that Sonora is like Persia and Palestine in the luxuriance and richness of its fruits. The pomegranate, apricot, orange, and lemon, are found in perfection, though the area is not large in which they are quite successful. In California the mission establishments were surrounded by magnificent fruit gardens; grapes, figs, pears, and other fruits of the warm temperate zone, are in the highest degree successful. The great unoccupied tracts of New Mexico and Utah which are next to these in position will clearly permit some degree of similar cultivation. It is remarkable that wheat, the crowning form of the cereals, attains a perfection in California beyond anything previously known. The grasses are half grains there also, covering the earth with their seeds so profusely when the growth ceases at midsummer that cattle sustain themselves by gathering the seeds alone. Wild oats are abundant over the greater part of the south of this State also, and valuable both as grass and grain.

Two conspicuous forms of vegetation have been alluded to as characteristic of the interior here, yet not abundant in the old world; the cactus and artemisia. The last is here certainly one of the chief social growths, and almost as abundant as the heaths of the uncultivable plains of Europe and Asia. There are no heaths here, nor does the sage (artemisia) supply their place, since the heaths go wherever low temperature and retentive, half barren soils prevent cultivation, without regard to the quantity of rain or degree of humidity. The artemisia occurs only where it is conspicuously dry and sandy, or alkaline. Some of the topographical officers have found it on soils which would produce wheat, but generally it characterizes soils wholly unfit for grass and grain.

There are many other forms of compositæ and saline plants, with a large class of chenopodiaceous shrubs, which here seem to be particularly adapted to arid and alkaline soils. The *larrea*, or grease-wood, is an offensive and worthless plant, which is often as abundant and conspicuous as the artemisia.

The same saline and alkaline plains exist in Asia with a similar class of plants, but there seems to be a greater variety there on the whole, and, apparently, a less exclusive possession of the ground by any one except the heaths.

In this general comparison the characteristic interior grasses are worthy of notice, on this continent particularly, though there is no definite knowledge what they are in Asia. In both cases they doubt-

less differ extremely from the cultivated grasses of the west of Europe and the Eastern United States. They certainly do so here, yet there are several species of great value and of very general extension over the country, precisely adapted to its arid climate. The principal form is the Buffalo grass or grama, of which there are several species or varieties.* The characteristics of this grass are its great measure of nutritive qualities, and its retention of these after being dried by the heats of summer, so that as long as it remains cattle may be supported on it. It is perennial on a strong tuft of roots, and with a narrow, curled, and slender leaf, and stem of moderate height. Its range is from the 96th meridian at the south and the 98th at the north, over all the dry area of the plains, and over much of the more level portions of the mountains south of the 40th parallel. It is the chief support of the immense herds of Buffalo which have roamed over this district for an unknown period, and for the space it occupies, and its value in such a region, it is entitled to a high rank among the growths of the interior. It is not known that any representative exists in Asia.

There are some valuable species of *festuca* of extensive range in the mountains, and beyond the range of the grama, which deserve to be noticed in speaking of the grasses. Though valuable single forms undoubtedly exist in Asia we are now ignorant what they are, or whether any are as conspicuous as the American. From the tone of the descriptions we have of the steppes however, it would be reasonable to infer that the vegetation was more varied, and that such immense wild herds as have long existed in North as well as South America would not find support in the interior. These steppes and plains have been inhabited by pastoral nations from time immemorial it is true, and perhaps to this cause alone the absence of wild herds is to be attributed. Humboldt (Aspects of Nature) remarks:

"Some of the Asiatic steppes are grassy plains; others are covered with succulent, evergreen, articulated soda plants; many glisten from a distance with flakes of exuded salt which cover the clayey soil not unlike in appearance to fresh fallen snow." "In travelling the pathless portions of these steppes the traveller, seated in the low Tartar carriage, sees the thickly crowded plants bend beneath the wheels, but without rising up cannot look around him to see the direction in which he is moving." "These Asiatic steppes, which are sometimes hilly and sometimes interrupted by pine forests, possess (dispersed over them in groups) a far more varied vegetation than that of the Llanos and Pampas of Caraccas and Buenos Ayres. The finest part of these plains,

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* Torrey gives the name of *Chondrosium* to two of the larger species of the grama, in an examination of Col. Emory's collections in 1847, and that of *Sesleria dactyloides*, after Nuttall and Fremont, to the smaller grama, or the "Buffalo grass" proper. From their habit and the subsequent examinations of officers of surveys they appear to belong to a single genus, with marked characteristics as such, and possessing many varieties.

which is inhabited by Asiatic pastoral tribes, is adorned with low bushes of luxuriant white-blossomed rosaceæ, fritillarias, tulips, and cypripedias."

As the existence of the elevated and arid plains of North America similar to the steppes, has become known only since the surveys of Fremont, Humboldt makes comparison only with those of South America. Little analogy could be expected between the Asiatic and the South American plains, except, perhaps, at the extreme south in the Pampas of Buenos Ayres; and the conditions of these last are widely different in respect to altitude, latitude, and continental position, from those of Asia.

SPECIFIC NOTICES OF THE CENTRAL BASIN.

The Central Basin region defined by Fremont is the least known division of the western climates, and whatever detail is accessible in regard to it, in any shape, may be worth a place in illustration of our interior climates. The whole area is included in the description previously given of the western half of the continent, and it might have been passed over with the notice belonging to it in that connection, yet there is a propriety in distinguishing it more decisively because of the real importance it has, and of the absence of adequate attention to it heretofore. There is a belt, or line of basins in fact, of which the Salt Lake Basin is the central area; and which differs only in degree through its whole length from the Columbia River at Fort Colville to the head of the Gulf of California; and, indeed, to the southern point of the Californian peninsula. This geographical fact has been alluded to elsewhere, and the purpose of the present climatological distinction is mainly to signalize these facts of difference by giving what is known of the salient features of the climate of the Salt Lake Basin in a separate form.

Until the first exploration by Fremont, in 1842, geographers did not recognize the existence of any basin on that part of the continent; the Buenaventura River was drawn as the outlet of the Great Salt Lake, which was then designated as Lake Timpanogos, and which had then been quite accurately placed by Humboldt. In most maps at least one other river of large size was drawn to drain the district southwestward between the Buenaventura and the Colorado. Fremont sought the Buenaventura long and anxiously on his journey southward from Oregon, in the winter of 1843–1844, and in his efforts to extricate himself through the Sierra Nevada, suffered the greatest possible hardships. He found an immense area bounded by this sierra as a gigantic, unbroken wall at the west, and by ranges at right angles to it, as he supposed, on the north and south, to

have no external drainage whatever; and that it had also an extremely rough, elevated, and arid surface, with salt lakes and salt plains in every part. The climatological importance of this configuration is scarcely less than the changes of geography, simply, and it would have given a widely different tone to our entire conception of the American climate, if the original access to the continent had been from the west instead of from the east.

Fremont's review of the specific central basin at the time of his first completion of the circuit which defined it and proved its existence, forcibly characterizes the district:—

"On arriving at Utah Lake, we had completed an immense circuit of twelve degrees diameter north and south, and ten degrees east and west; finding ourselves in May, 1844, on the same sheet of water we had left in September, 1843. . . . I had seen the Great Salt Lake, and the Wahsatch and Bear River Mountains, which enclose the waters of the lake on the east, and constitute, in that quarter, the rim of the Great Basin. Afterward along the eastern base of the Sierra Nevada, where we travelled for forty-two days, I saw the line of lakes and rivers which lie at the foot of that Sierra, and which Sierra is the western rim of the Basin. In going down Lewis's Fork and the main Columbia, I crossed only inferior streams coming in from the left, such as could draw their water from a short distance only; and I often saw the mountains at their heads white with snow, which, all accounts said, divided the waters of the desert from those of the Columbia, and which could be no other than the range of mountains which form the rim of the Basin on its northern side. And in returning from California along the Spanish trail, as far as the head of the Santa Clara fork of the Rio Virgen, I crossed only small streams making their way south to the Colorado, or lost in sand as the Mohahve, while to the left lofty mountains, their summits white with snow, were often visible, and which must have turned the water to the north as well as to the south, and thus constituted, on this part, the southern rim of the Basin. The existence of the Basin is, therefore, an established fact in my mind; its extent and contents are yet to be better ascertained. It cannot be less than four or five hundred miles each way, the latitude of 42° probably cutting a segment from its northern rim. Of its interior little is known. It is called a desert, and from what I saw of it sterility must be its prominent characteristic, but where there is much water there must be some oasis. The great river and the great lake reported, may not be equal to the report, but where there is so much snow there must be streams; and where there is no outlet there must be lakes to hold the accumulated waters, or sands to swallow them up. In the eastern part of the Basin, containing Sevier, Utah, and Great Salt Lakes, and the rivers and creeks falling into them, we know there is good soil and good grass adapted to civilized settlements. In the western part, on Salmon Trout River and some other streams, the same remark may be made."

"That it is peopled we know, but miserably and sparsely. From all that I heard and saw I should say that humanity here appeared in its lowest form, and its most elementary state. Dispersed in single families; without fire-arms; eating seeds and insects; digging roots, (hence their name)—such is the condition of the greater part. Others are a degree higher, and live in communities upon some lake or river that supplies fish, and from which they repulse the miserable *Digger*. The rabbit is the largest animal known in the desert. . . . The wild sage (artemisia) is their only wood, and here it is of extraordinary size, sometimes a foot in diameter and six or eight feet high. . . . The whole idea of such a desert and such a people is a novelty in our country, and excites Asiatic, not American ideas."

Subsequent explorations give strong reason to believe, though they do not demonstrate the point completely, that neither on the north or south is there any abrupt chain of mountains, enclosing the basin, or forming its boundary there. All the mountain ranges are found to run from south to north, or southeast to northwest, and so far as the different parts of the Basin-region have been traversed, it has been found equally full of these as short, segregated, yet overlapping ranges; conveying the idea of a continuous chain from almost any point of view, yet full of basins, salt pools, lakes, and sand deserts between all these mountains. At the south those segregated short ranges are continued, at successively lower levels, to a point on the west of the Colorado, even south of its point of entrance into the Gulf of California, and they are scattered among the mountains east of the Colorado also. At the north, salt plains and minor basins are found south of the Columbia, and again beyond it, on what are called the great plains of the Columbia. There is much correspondence, in fact, throughout the whole line from Sonora to the 49th parallel, though the specific central Basin lies between 34° and 43° north latitude, and 112½° and 120° longitude west. The whole of the belt before alluded to is made up of short, detached mountain ranges, and of segregated basins and saline lakes, of which Great Salt Lake is the largest, and Humboldt River the largest stream.

The remark of Fremont, before quoted, in regard to the wood and native animals of these basins must also be qualified, as it is now known that at the borders of the district defined the transition is gradual to other localities, and that the inhabitants of these mingle more or less over the whole. Few other forest trees than the cedar, have been found in the region defined by Fremont as the Basin; this was found by himself, subsequently, and by Beckwith, at intervals, over the most forbidding line traversed by either. At the south and east Fremont found pine forests on the bordering mountains, with cottonwood in small quantity in the valleys tributary to the Colorado.* Antelopes were seen by Beckwith near the worst points he traversed, and there are exceptional localities scattered over it, without doubt, in every part. Still the district as a whole is in the most extreme contrast with our ideas of the vegetable production and life of the American climate generally, and it is not remarkable that when first

* On first striking the Rio Virgen from the west, Fremont remarks; "From the time we entered the desert the mountains had been bald and rocky; here they began to be wooded with cedar and pine, and clusters of trees gave shelter to birds—a rare and welcome sight—which could not have lived in the desert we had passed." (Return Journey of 1844.)

seen it should appear to be, as a necessary condition, distinctly and sharply bounded by mountains or other adequate causes of distinction.

The distribution of rain is one of the most important points in its climatology, and as there are no records of actual measurement, such references as we have from the very accurate observers who have traversed and surveyed it must be taken. From the narrative of Stansbury, who spent several months, closing with June, in the survey of the western shores of the Salt Lake; and from that of Beckwith, who was two months,—May and June—occupied in crossing from Salt Lake to the Sierra Nevada, it is clear that the succession of rains in spring and early summer is similar at that parallel to that which prevails at the same latitudes in the Atlantic States. Showers are frequent and irregular, and there is no tendency to periodicity apparent, for so much of the year. The winter months are similar, and much of the Basin region above the 41st parallel and on the eastern border appears to belong to the division of *equally distributed rains* for the winter and spring, and then to be in contrast with the remaining portions, or those at the south particularly. Fremont encountered showers in May, on the Rio Virgen, and he remarks that the desert here changes to the climate of the Rocky Mountains, as a distinction in approaching from the west. But it is probable that the change belongs primarily to the latitude, since those who have entered the desert at the western borders in the latitude of Las Vegas—37° 30′—have reported the existence of showers and rains in spring and the first month of summer.

The important distinction appears to be that the rains rapidly diminish in quantity without changing their character as to time and frequency in the sense of periodicity, until at the west and south they cease entirely. Such was Beckwith's experience at the 40th and 41st parallels, for the early part of the summer, to which season it is intended to apply the remark. For the latter months of summer a similar principle may possibly apply, but the deficiency of rain is greater, undoubtedly amounting to entire absence of it in the southern and western parts. Still it is asserted that clouds and the appearances of thunder showers have been observed over that part of the desert from the eastern slopes of the Sierra Nevada at the 35th parallel, and also within view from the lines travelled on the Mohahve River, at the time the summer rains are falling on the mountains south of the Gila —the intervening district being usually wholly without rain. Lieut. Williamson* mentions a heavy thunder shower on Aug. 17th, lasting

* Lieut. Williamson's Report of Surveys of Passes in the Sierra Nevada, 1854. (Octavo, p. 18)

between two and three hours, which he experienced at a plain or pass east of the principal range of the Sierra Nevada, lat. 35° 30′, long. 118°, and in the immediate border of the desert. The altitude was 4020 feet, and the desert tracts of the vicinity were but little lower.

It will be seen from these citations that the Basin region as a whole can hardly be said to be one of periodical rains, north of the 35th parallel, however deficient the quantity is, and however abortive—as it may be said—the rains are as regards vegetation and practical climatology. The rain of the summer, from the middle of June forward, is practically valueless in cultivation for the vicinity of Great Salt Lake, and the flourishing settlements there are sustained by irrigation. Cultivation would clearly require this aid everywhere, and as the winters are not available in bringing crops forward, as in California, irrigation may not be dispensed with, as it may be there. It is unimportant to many of the best crops of California, wheat among them, that there is no rain whatever in summer, since they are so far advanced in the mild winter that the summer is only requisite to ripen them. But in no part of the Basin is this adaptation practicable, so far as known. The extent of summer required is similar to that of like latitudes in the Atlantic States, and the deficiency of rain is therefore destructive, if irrigation is impracticable.

There is a feature of the rains of the summer to the close of June, —which is the whole period well known—in the northern part of the Basin that is worthy of notice. It is the abruptness of the changes of temperature, and the violence of the winds, apparently the incident of the great elevation of the whole plain. Snow is remarked by Beckwith, in June, at an altitude of but about 5000 feet, or at the general level of the district, and at this time it was frequent on mountains elevated but 2000 or 3000 feet more. The severe changes of temperature during these storms are noticed by Fremont and Stansbury also, and they are a characteristic of the climate as one peculiarly belonging to an elevated locality. The greatest degree of these changes is noticed by Beckwith in the lofty mountains of Northern New Mexico.*

The heat and rarefaction of the surface generally render this local atmosphere disproportionately arid over the whole Basin region, notwithstanding the frequency of rains, at all seasons. A very rapid evaporation is in progress apparently at all times, and it can hardly

* "Several times during the day (Sept. 5,) we experienced very sensibly the sudden changes of temperature to which high altitudes in mountain regions are subject from a passing storm or a change of wind—our thick coats being at one moment necessary to our comfort and the next oppressive." Beckwith's Report of Surveys, 1853 (Octavo, p. 51.)

be otherwise when even in the early spring the saline plains glitter with crystallizations; dissolved on one day perhaps by the rain, yet formed again almost immediately by its evaporation. Very few of the localities have external drainage, or unite their surplus waters with any stream or lake. Since the rains are frequent at some points, and for some parts of the year, this must be conclusive evidence that the evaporation is very rapid. Stansbury thought the haze which almost constantly obscured the instrumental observation and triangulation at Great Salt Lake—a tremulous mist, or haze, and not a fog—was occasioned by the rapid evaporation alone, and the exaggerated mirage of these saline plains is probably due to the same cause.

The temperature of evaporation, or that of the thermometer covered with wet gauze, was observed at Great Salt Lake for some months (Dec., 1849, to April, 1854) by order of Capt. Stansbury, but as these were for the colder months it is difficult to compare them with others. Great care is necessary to accuracy in such observations, and no precise mention is made of the care exercised in this case, and no conclusions are deduced. It can only be said that the differences are large in clear weather, and that on some days in April they reach 15° to 20°; and this when the air temperature, dry, is less than 70°. Full observations of this character at Salt Lake would evidently correspond well with those taken in New Mexico, where the average differences between the wet and dry thermometer—the direct test of the local condition in respect to moisture—are twice as great as in the Atlantic States.

The temperature has some points of distinction beyond those already alluded to. The general amelioration of the Pacific climates is felt in the fact of a *mean* temperature differing little from that of the Atlantic States in the same latitudes, notwithstanding its elevation of 4500 to 7000 feet. It is as warm, in the annual mean, also, as the immediate coast of the Pacific, which is here cooled by extraordinary influences in summer, however. The few records of temperature we have here show that the analogies of deserts and elevated districts prevail at Salt Lake—a high mean for the warmer months with a great daily range. The measure of thermal effect—if it may be so termed—is also different from that of the eastern United States; the heat of the arid atmosphere under its condition of great daily variation, not promoting as rapid a degree of vegetable development as in a moist atmosphere. This is probable from the local cooling of plants and radiating bodies themselves when in an absorbent atmosphere, in addition to the consequences to which they are passively subjected. At Great Salt Lake the cultivation of Indian corn is difficult and not profitable, though the mean temperature of the three requisite months

must exceed 75°, which is 10° above the mean at the climatological limit near the sources of the Mississippi. Other growths, and particularly fruits may not be influenced to a like degree, and they are clearly better adapted to such climates both in Asia and America, than the great staples of the Eastern United States which are nearly coextensive in their range east of the Rocky Mountains. The fruits fail sooner than corn and tobacco in the last mentioned case, and that by a large difference of latitude. The peach is hardly known in Maine, Canada, and Minnesota; where both corn and tobacco are easily grown, and sometimes very successful. It is probable that the peach and kindred fruits will attain great perfection in most of the Basin region, and in the vicinity of Great Salt Lake, where Indian corn is quite unreliable.

From the high temperature shown in the summer and annual means in the district under consideration, a deduction is therefore necessary to compare it with the practical consequences of such temperatures elsewhere; a deduction due, probably, equally to aridity and to elevation. And the last cause acts through the first by the depression which occurs when evaporation and radiation are going on, rather than directly, or from elevation alone. No recognized rule of reduction in the measure of heat for the altitude, as applied in Europe, applies here at all, and as the means are computed no reduction whatever is required,—the mean temperatures being as high as those at sea level on either side of the continent. The equivalent of 5000 feet of elevation, would, for the average of Central Europe, be equal to about 17° on the mean temperature. This added to the observed temperatures at Great Salt Lake would make them extra-tropical for the summer, and almost tropical for the year. Evidently no such correction is required here, and the consideration of altitude can only be retained as associated with the causes of daily variation, and with other incidents of temperature, as they may be called in comparison.

The early and late frosts, and the chills brought suddenly on the valleys by local storms are sufficient, as prominent single conditions, to cut off the successful cultivation of Indian corn and of other staples as sensitive as this. Hardy cereals, and fruits of even delicate sorts might, however, be greatly successful in these very localities, and so far as known they are so. The conditions are so nearly like those of Asia Minor and the Caucasus, that like extremes of local position may be anticipated, and a similar variety—under general conditions, however, which quite completely shut out the classes of which Indian corn is the most definite type.

The sum of conditions in the Basin climates is not only in contrast with that of the eastern area, but also with that of the Pacific district

as a whole, on the points that have been noticed. The latitude and altitude place much of the country at the border of the *periodical* climates, and where the facts of rain fall and of temperature range conform to the *equally distributed* division, while the resulting effect upon cultivation conforms to the *periodical* class of climates. At the southern border again the tropical features are intruded from the north of Mexico, and the summer rainy season which gives profuse moisture at a little distance south of the Gila River, is intruded into the Great Basin as a *tendency*, which may attain to profuse rains, or may pass without any. On the high mountain ranges east of the Colorado and near the Rio Grande the summer is a fully established rainy season, conforming at the south to tropical associations, and at the north to the characteristics of mountains of the eastern United States in summer. Yet for all the valleys among these well watered mountain summits irrigation is necessary to cultivation, so abrupt are the changes of the practical sort, or those of actual climate, where the exterior laws would imply sufficiency of rain.

In regard to all parts of the Basin region the theories of climate, or the laws of exterior character, are of extreme interest, and the study of these would, more readily than anything else, assist the solution of the entire system of laws for the temperate latitudes. But there is not yet a sufficient accumulation of observations to make a discussion of these points clear, and practical comparisons are the best that can be made in decisive form. In all the desert belts there are cultivable and even rich localities, and the basins here have as large a proportion of such localities as Arabia and Persia. Wherever irrigation is practicable in such climates the productive capacity is always ample, and the number of small mountain streams in a district so universally rough, will multiply cultivable localities much beyond the present anticipations of those who have visited the district. With a reduction of the average temperatures of two or three degrees on the monthly means, to obtain the equivalents of the averages at the east in their bearing on the cultivable capacity, there is still a high measure of heat for all parts of the basins. At Fort Yuma the mean for the year is 73°.5, and that for the warmest month 93°; measures only equalled in the lowest basins and valleys of Arabia. There are tributary valleys of every grade, particularly on the east of the Colorado; and in ascending to the high plains of New Mexico, which are still cultivable at 8000 feet above the sea, there must be a rich variety of local climates encountered, as in the ascent from the Persian Gulf to the valley of Cashmere. Though New Mexico is not in the special basin region, the same local advantages are known to exist on the eastern slope of the Sierra Nevada, and on such mountains as have been visited at the

eastern side of the basin on the Spanish Trail; and also at the existing settlements south of Great Salt Lake.

The mean of the coldest month at Salt Lake is 28°, or 2° below that at New York City at the same latitude, though the winter observed at Salt Lake was colder than usual, and its average temperature is probably fully equal to that at New York. At Fort Yuma the coldest month is 56°, or 6° warmer than the mean of the same month at Charleston, at the same latitude on the Atlantic coast. The average altitude of the basin proper cannot be less than 4000 feet for its lowest plains, and 5000 feet for the plateaus at the borders; thus differing largely in this controlling element of configuration, for the upper or northern part of it at least. How the transition from the upper to the lower part is effected is still obscure, but the narrow and segregated valleys and peculiar mountain ranges probably succeed each other toward the south at small differences of altitude, and thus a descent to the Colorado is effected without the occurrence of any lateral range of mountains, or abrupt step of any sort.

VI. DISTINCTIVE FEATURES OF THE PACIFIC COAST CLIMATES.

THE Pacific coast of this continent differs from the west coast of Europe in some conspicuous points, though the two are generally similar, in accordance with the analogies of continental position. These points of difference affect the sensible climate very much, and are prominent in all its practical relations. For nearly the whole line of coast in the United States the normal curve of temperature through the successive hours of the day, and through the successive months of the year, is very much reduced, and at Monterey and San Francisco it almost disappears during the warmer months. The resulting *equality* of temperature can hardly be designated *equable*, since the reduction appears as a harsh degree of cold because of its displacement of the natural condition. The winter and cooler months are delightfully equable on the whole coast, but the summer is harsh, and widely different from the summers of Europe which have the same temperature for the winter. This reduction of temperature is due to the joint action of the heated surface of the interior and the cold mass of waters off the coast, the last being peculiar to the western coasts of this continent, and unknown to the corresponding coasts of the old world. There are many distinct incidents or results derived from this reduced temperature, and all that relates to it constitutes the distinction from the west of Europe, though for our own illustration some of the European peculiarities may require to be named.

In distinction from the Eastern States the slight range of all other conditions is very noticeable, in non-periodic as well as periodic vibrations. The barometer varies little, and that through slow and long continued movements, rather than in the abrupt manner characteristic of these latitudes elsewhere. If there are symmetrical gradual changes, also, they are far more rare at any season, and they never occur in summer. The contrast between San Francisco and Norfolk or Charleston is very great in this respect, and instead of the abrupt and extreme oscillations so constant on this coast, there is nothing

there which may be ranked with such movements, and the uniformity is nearly as well marked as in the tropics. It is not known how large a share of the surface of the Pacific off the coast belongs to this quiescent area, but the great storms of the east coast of Asia appear to be exhausted long before reaching California; and though they have, where they originate, the extreme oscillations of barometer and of temperature which are found in the storms of the Gulf Stream, they are certainly not continued across the ocean area at the latitudes in which they originate. If similar to the storms of the Atlantic in regard to movement along the warm water currents to higher latitudes, they must still be exhausted at a greater distance from the shore of the continent, and it is doubtful whether they are felt at all in the latitude of Vancouver's Island in the summer months, though in England the storms of the Gulf Stream often occur in summer.

The rains of the Pacific coast are periodic also, and in this respect they differ entirely from those of the west of Europe in corresponding latitudes. It is not easy to account for this difference, and particularly for the fact that this periodicity is continued to the 48th parallel. At Sitka, lat. 57°, it almost disappears, however, and the year is nearly equally rainy throughout. Though we know little of the condition at Vancouver's Island in this respect, it is probable that there are decided features of periodicity there, only in less degree than those at Puget's Sound and the coast southward, and yet greater than those of like latitudes of the coast of the British Islands. This periodicity appears in the phenomena attending the rains—the nearly constant southeast winds, and the intensified local or sensible humidity.

It is true that these points are mainly differences of degree from the conditions at the various latitudes of the west of Europe below the 45th parallel, but they form conspicuous differences of the sensible climate, and in comparison with the eastern states they form marked contrasts. The central latitudes of France first show decided interruption of the continuity of rains for the summer, and they do not cease altogether at any point north of the Spanish peninsula, the difference of latitude being three or four degrees between that and the point of summer discontinuance of rain here.

The rains of this best known portion of the Pacific coast, are, as has been said, peculiar in regard to the attending winds, which from San Diego to Puget's Sound, are, in nearly all cases, from the southeast and south with a strong and steady force. There are, also, simply *attendant* winds, and not those which may be said to bring the rains,—the course of clouds above the local or surface wind being quite regular from the west. But no sooner is precipitation begun than the

attendant southeast wind sets in, to be continued steadily to the end of the rain in most cases. And at the northernmost stations it begins always earlier than at the next southward; in fact beginning and ending with the rain in all cases, and as they begin earlier at the northerly points it has more days of duration there. The direction of the wind is apparently dependent on the trend of the coast and the mountain ranges near it, and where these are from south to north quite directly, the wind is nearly from the south. It is so at Fort Steilacoom on Puget's Sound, and at other places similarly placed.

Why the aspiration induced by the periodic rains of this long belt of coast should be from the south it is difficult to say. It is, however, one of the instances of uniformity and equality existing here in contrast with the Eastern States.

In the next chapter some statistics of the temperature curve among the months are given, comparing them with the more equable climates of the west of Europe. The analogy is exceeded at some points on the Pacific coast, or the singular result is found of a reversal of the normal curve for a few months, making the spring and autumn both warmer than the summer. The cause of this is extraordinary, and scarcely climatological, yet so large a belt of coast is influenced as to give the phenomenon great importance. The apparent cause will be stated somewhat at length in explanation of the thermal distribution, and the general fact only need be given here. Apparently an immense cold current approaches the coast here at 35 to 45 degrees of latitude, which in summer exercises a wide and decisive influence on all the included coast, its maximum and central point being nearly at San Francisco. The temperature is not only kept at the average of the earlier months of the summer, but it is made to fall below that temperature at exposed points. This anomaly appears most distinctly at San Francisco, where October is equal to July, and September the warmest month of the year. The range between the months of January and July is 8°.3 only, while at Washington it is 44°.2, or more than five times as great.

This coast atmosphere, though of low temperature, does not appear to be as humid as that of England and France, notwithstanding the large quantity of sensible moisture, fog or mist, on the sea winds at San Francisco. Below or south of the Columbia River it is mainly dry and bracing at all seasons, or the general climatological effect is such, in contrast to that at Sitka where the saturation is excessive, and the quantity of rain like that at Bergen, in Norway. The low temperature southward is a single and distinct condition, as it appears; and if it were removed the whole coast would much more nearly correspond with that of Europe, where, as along the west of Spain and of

Portugal, the prevailing features for this season are dryness and serenity.

Thus the Pacific coast climates are Norwegian, English, and Spanish or Portuguese; with the intermediate France blotted out, and an anomalous temperature substituted, so cold at midsummer as to cut off the vines and corn which ought to be found there. All these are confined to narrow districts or lines also, throughout the entire extent of coast, and they never penetrate the interior or influence very large islands, except that of Vancouver, and no peninsulas. The coast south of Vancouver, is iron-bound, in technical phrase, with few indentations or deviations from a right line to add to its amount of exposed surface. For these reasons the sea influences are of less importance or penetrate less than they otherwise would, and these points of identity with other districts remain but little known.

Dr. Gibbons has recently defined some points quite carefully in the course of observations at San Francisco.* He says in regard to storms,

"The easterly storms which form so prominent a feature of the Atlantic climate are unknown here; there is nothing that bears any resemblance to them. The rains from southeast are often attended with high gales, which extend over a large portion of the western coast of North America and inflict some injury on shipping, but these gales are less violent than the severe easterly storms of the Atlantic coast. The direction of the cloud producing the rain is often of greater importance than that of the lower atmospheric current. There are usually two strata of clouds, the lower concurring with the wind on the earth's surface and seldom supplying rain, and the higher, which is the true rain-cloud, varying in its course from the lower, and sometimes having the very opposite direction. In sixty-seven instances furnishing an opportunity to observe the upper cloud its course was as follows: N. E. 1; N. and N. W. 7; W. 16; S. W. 23; S. 14; S. E. 6. These results concur with observations made in the Atlantic States showing that the higher strata of the atmosphere which sweep northward from the equatorial region saturated with vapor are the principal source of rain to the temperate latitudes."

"In almost every month of the year, even during the dry season, the clouds put on the appearance of rain and then vanish. It is evident that the phenomena which produce rains in other climates are present in this, but not in sufficient degree to accomplish the result except during the rainy season, and then only by paroxysms with intervening periods of drought."

In a summary of observations for sixteen months from Dec. 1850, to March, 1852, he gives the number of days of the presence of an upper cloud as 365, and of the presence of lower clouds as 366.

"The lower cloud was deficient most frequently in the rainy season, but present almost daily in the dry season. The upper cloud was most wanting in the dry season, and especially in July. . . . . The higher currents of the atmosphere, as indicated by the clouds, pursue the same general course as in the Atlantic States."

For the same sixteen months the classification of the winds attend-

* Am. Jour. of Science; Essays in California Journals, &c.

ing the whole number of rains at San Francisco, which was 79, is given by Dr. Gibbons as follows: east and northeast 2; north and northwest 8; west and southwest 25; south and southeast 44. Thus from the quarter attending most rains of the Atlantic States there were but two instances, and the most frequent quarter was southeast. "The most rainy point is in a direct line with the southern coast, or about south-southeast."

The proportion of cloudy days at San Francisco is stated by the same authority as very low, contrasting it with Philadelphia he puts the number at less than one fourth. The difference of localities is very great in this respect, however, as the military post, which is a little nearer the sea, and more under the influence of coast mists, gives a much larger number of cloudy days than that observed by Dr. Gibbons. Farther in the interior it is well known that the clouds still more completely disappear, giving, for the valleys of the San Joaquin and Sacramento, a sky remarkably free from clouds. As compared with the Atlantic coast the clouds are singularly inconstant in every part of California, as is particularly noticed by the same authority.

The most remarkable phenomenon of weather there is the summer coast wind and its attendant mists. This seems to be due solely to the proximity of districts of great heat and sudden rarefaction on the land, to the cold mass of waters off this coast, and to its refrigerated surface atmosphere. A maximum day temperature of 110° is often experienced at Fort Miller, a point in the San Joaquin Valley, when at the same time off Monterey and San Francisco the sea and sea wind are at 55°. Such extreme contrasts existing at sea level and not far apart must be expected to originate violent winds, and it is only wonderful that they are not more severe at the passes giving access to the interior. They are characteristic of the whole district so contrasted in summer, which begins a little above Fort Orford on the coast of Oregon, and ends completely only at the southern extremity of Lower California; though it is not severe below the 34th parallel. The relations of some of the more extraordinary winds of the United States, this included, to local and extraordinary causes have been examined by the author in previous papers* in which its daily character and its cessation at night are accounted for by its low latitude.

"As this blows, however, without being aided by the circulation of surface atmosphere usually received as the normal one, it has not the absolutely continuous character it would have if it accorded or nearly accorded with that circulation."

It is in latitudes so low as to be influenced by these contrasts of

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* The Abnormal Atmospheric Movements of the United States; Proc. American Association for the Advancement of Science, 1853.

temperature only, and it is consequently a day wind, and most violent when the contrast is greatest.

Dr. Gibbons describes these winds as follows:

"Whatever may be the direction of the wind in the forenoon, in the spring, summer, and autumn months, it almost invariably works round to the west in the afternoon. So constant is this phenomenon that in the seven months from April to October inclusive there were but three days on which it failed to do so, and these were rainy. The sea winds are moderate until May, when they begin to give trouble. In June they increase in force, reaching their greatest violence at the beginning of July. In August they decline in force but not in constancy; in September they continue steady though moderate; and in October they lose their annoying qualities and become gentle and agreeable."

The point from which the wind blows is somewhat variously stated at southwest to northwest, but off the coast, where no causes of local deflection exist, it is nearly at northwest; or simply from the coldest part of the mass of cold water. As this approaches from the northwest the winds are usually at that point.

Dr. Gibbons gives the percentage of sea to land winds for 1851; based on three observations daily:

January	sea winds . . 44 per cent.		July	sea winds . . 97 per cent.	
February	" . . 63	"	August	" . . 97	"
March	" . . 81	"	September	" . . 96	"
April	" . . 86	"	October	" . . 78	"
May	" . . 95	"	November	" . . 73	"
June	" . . 96	"	December	" . . 38	"

The winds of five months of the summer are seen to be almost wholly from the sea.

The attendant mist is peculiar, and it is evidently a condensation produced by contact of the cold air alone, and not by natural condensation in the volume coming from the sea. The air out at sea is usually clear and the mist only forms a narrow rolling line along the place of contact of the volumes differing so widely in temperature. Any cold jet of air intruded into a mass having a high temperature will produce a similar condensation. To quote again from the graphic accounts of Dr. Gibbons:

"The sun shines forth with genial warmth, the mercury rising generally from 50° at sunrise to 60° or 65° at noon, but when the sun has reached the zenith the wind rapidly increases, coming down in gusts from the hills which separate the city from the ocean, and often bringing with it clouds of mist. But the dampness is never sufficient to prevent the elevation of clouds of sand and dust which sport through the streets in the most lively manner. The mercury falls suddenly, and long before sunset fixes itself within a few degrees of 50°, where it remains pertinaciously till next morning; often not moving a hair's breadth for twelve hours. . . . The mist often increases towards evening and when the wind falls remains all night in shape of a heavy fog. Sometimes, when the sun has been shining brightly the mist comes in from the ocean in one great wave and suddenly submerges the landscape. In short there is no con-

ceivable admixture of wind, dust, cloud, fog, and sunshine that is not constantly on hand during the summer at San Francisco."

Sometimes this mist falls in a palpable fine rain, and it generally gravitates towards the earth as fast as formed. It is evidently the condensed moisture of the heated air of the interior, which though intensely dry when at its very high temperature, must necessarily condense moisture in cooling thirty or forty degrees, and to little more than half its measure of heat on the surface and in the full exposure to the sun.

More or less of this local effect along the Pacific coast is experienced soon after leaving the coast of Mexico at Mazatlan, and protection from cold head winds is said to be required at all points along the coast of Lower California even in summer. The contrasted temperatures extend to that point, Cape St. Lucas, and, though they are not so greatly contrasted as at San Francisco, they still produce a *cold* sea breeze. It is in summer only that these effects are felt, and that the local peculiarity exists in the temperature of the sea. In winter the water is actually warmer than in July, apparently because the force driving the cold current from the northern seas has become greatly weakened, and the current being less, it is perhaps overlaid by the warm waters of the average of that sea in those latitudes. In winter, therefore, the disturbance or anomaly ceases which forms so singular a feature of the climate of the warmer months for near twenty degrees of latitude.

North of the 45th parallel the cool, humid summer of the west of the British Islands and Norway exists, with, apparently, no great measure of difference in like latitudes. It is little known as yet except on the coast of Oregon and at Sitka, but where not shut in by rugged mountains it is very favorable, at least to the 55th parallel. Vancouver's Island is peculiarly favored, and its area is large enough for a flourishing State. It is said that here the summer is warm and productive, and that all branches of agriculture common to the latitude, 48° to 52°, in Europe flourish whenever undertaken. It cannot be otherwise than that a large area of valuable lands and favorable climate extends between this point and Sitka at lat. 57°. At this last point the saturation becomes excessive in summer as well as at other parts of the year, and there is almost constant cloudiness and rain. Richardson says* that

"The climate of Sitka is much warmer than that of Europe at the same parallel, but the atmosphere is charged with vapors whose condensation occasions almost constant rains. In the month of July the sun is seldom visible more than three or four days, and then only for an instant. The humidity gives astonishing vigor to the

* Arctic Expedition in search of Sir John Franklin.

vegetation, yet corn does not grow there, and, in fact, the want of level surface is an impediment to cultivation."

The same authority—the facts are taken from Bongard—speaks of the dense forests growing here, in which pines and spruces attain a diameter of seven feet, and a height of 160 feet.

It is unfortunate for the productive capacity of that side of the continent that the mountains are so near the coast, and that the climate changes so soon in consequence. Its singularly equable character in almost every respect has, for this reason, a range so narrow as hardly to permit adaptation to it, and its narrow limits have kept it long obscure. At San Francisco but a few miles of distance separate conditions extremely unlike, and in Oregon, if the temperature does not change so abruptly, the humidity does. Along all this immediate coast Indian corn, the characteristic American staple, fails to come to perfection, and at the greatest exposures will not grow at all. In the valleys opening to the sea it will often grow a slender stem of nearly full height, but with no tendency toward formation of the grain. The summer at Vancouver's Island is more favorable to it than that at Monterey, thirteen degrees of latitude southward, though it is believed that it is scarcely cultivable at the first locality—at least its cultivation there does not appear in notices of that island.

The elastic atmosphere and bracing effect of the Pacific climates constitutes a striking difference from those of the Eastern States. Whether due to the absence of humidity alone is not clear, but to whatever cause it is a notable practical feature. The interior valleys where the heat is excessive are similar to the cold coast also, and there is no climate which is not the reverse of enervating, in its whole extent. It has generally been held that this distinction has its origin in the quantity of atmospheric moisture attending the heat, and this is probably true for the most part, and particularly so of the eastern United States. If, as before stated, the moisture of the sea air on the Pacific is relative rather than positive, or is developed by the contact of great extremes of temperature, the whole may be taken as more dry than it would at first appear to be, and its uniformly bracing character will not be difficult to account for. As it is, all residents concur in pronouncing it more favorable to physical and mental activity than any they have known, from whatever quarter they come. The heat of the south, where the peculiarities of Spain are reproduced, is never enervating, and that of the excessively hot valleys of the interior is singularly endurable. This appears to be a characteristic of as much of the west coast of Lower California as is now known, as well as of the interior districts corresponding in position, the Gila River country and Sonora.

In the last, however, there are intensely heated districts like the desert at Fort Yuma, where the heat alone is stifling from mere excess, though the air is intensely arid.

There has yet been no competent observer on the spot who has taken up this point and has analyzed the singularly invigorating elements that prevail along so great a range of habitable coast. Nothing is clearer than that they are present in unusual measure, and perhaps they are due to the low summer temperature concurring with a minimum of moisture, and with the peculiar state of this minimum quantity.

At about the 36th parallel the vine climate begins, and from this point to one opposite to the head of the Gulf of California, the softness and uniformity of the South of Spain fully establish themselves. The temperature of San Diego is very nearly like that of Lisbon, differing less than half a degree on the average for each month and for the year, and it is the same, with singular uniformity, at Cadiz. At each of these points the lowest month has a mean of 52°, and the highest of 73°, the mean for the year being 62°. The average of differences is thus less than 2° for each month, and with a summer temperature much less than that of New York they have a winter warmer than that of Charleston. As the interior of coast districts of this character always presents favorable localities and a temperature curve higher at the maximum, they develop the vine climates of greatest value everywhere. Such is the case in California as decidedly as in Spain, though for a district less extensive, probably.

The climatological capacities of this part of California were very thoroughly tried at the establishment of the Missions, which had so singular a course of prosperity and decay previous to the acquisition of that country by the United States. At these establishments irrigation was employed when necessary, and they represented the efficient and consolidated labor of a large number of men, usually of native inhabitants, the Indians, directed by the priests who had control. Colton* has given a resume of the condition of these mission-establishments at the time of their secularization in 1834, or, as in some cases, at some date not long previous, with notices of their condition in 1849. These notices are so strikingly illustrative of the distinctive features of climate and productive capacity, that they may be given in a condensed form here.

The *Mission Dolores*, on the south side of the Bay of San Francisco, two miles from the town, had, in 1825, over 3000 horses, 820 mules, 77,000 head of cattle, 79,000 sheep, and other stock; with 18,000 bushels of wheat and barley as the year's growth, and great quantities of merchandise and specie. It fell to ruin very soon after its secularization in 1834.

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* Three Years in California, by Rev. Walter Colton, U. S. N., 1850.

The *Mission of Santa Clara*, in the valley of that name at the head of San Francisco Bay, had, in 1823, near 7,000 horses and mules, with very nearly the same number of cattle and sheep as in the previous case. It had splendid fruit also, and "has still a fine vineyard, where the grape reels and the pear mellows." By the state census of 1852, Santa Clara County had 16,800 grape vines. Lat. 37° 30′.

The *Mission of San Josè ;* this was founded in 1797, fifteen miles from the town of San Jose, and in a very fertile valley. It supplied the Russian Company with grain for a long time ; and "it is stated in the archives of the mission that the mayor-domo gathered at one time 8,600 bushels of wheat from 80 bushels sown." Three thousand Indians were employed by it in 1825, and its stock of horses and cattle was nearly equal to that first named. "It has still a vineyard in which large quantities of luscious grapes and pears are raised."

Mission San Juan Bautista ; ten leagues from Monterey in a rich valley ; founded in 1794. In 1830 it owned 43,870 head of cattle, 1360 tame horses, 4870 mares, colts and fillies. It had seven sheep farms with 69,530 sheep ; while the Indians attached to the mission drove 321 yoke of working oxen. Its store house contained $75,000 in goods and $20,000 in specie."

Mission of San Carlos ; founded in 1770, in Carmel Valley, three miles from Monterey. Its gardens supply the vegetable market of Monterey ; its pears are extremely rich in flavor. The first potatoes introduced into California were cultivated here in 1826. Its quantity of horses and cattle was greater than any before named.

Mission of Santa Cruz ; this stands on the coast on the northern side of the Bay of Monterey. In 1830 it had 42,800 head of cattle, 3200 horses, 72,500 sheep, &c.

Mission of Soledad ; in a fertile plain, fifteen leagues southwest of Monterey. This was watered by an aqueduct fifteen miles in length, supplying twenty thousand acres of land. This estate had immense numbers of horses and sheep ; "horses were given away to preserve the pasturage for cattle and sheep." In 1819 there was gathered here 34,000 bushels of wheat from 38 bushels sown. "It has yet standing about a thousand fruit trees which still bear their mellow harvests."

Mission of San Antonio. This is twelve leagues south of the last named,—"its lands were forty-eight leagues in circumference." A stream was conducted twenty miles in paved trenches for purposes of irrigation. Its property was like those previously named. "On its secularization this mission fell into the hands of an administrator who neglected its farms, drove off its cattle, and left its poor Indians to starve."

Mission of San Miguel ; sixteen leagues south of San Antonio, on a barren elevation, but with lands sixty leagues in circuit embracing many fine tracts. It had immense herds.

Mission of San Luis Obispo,—fourteen leagues southeast of the last named, and near the coast. "The presiding priest, Louis Martinez, was a man of comprehensive purpose and indomitable force. Every mountain stream was made to subserve the purposes of irrigation ; he planted the cotton tree, the lime, and a grove of olives, which still shower their abundant harvests on the tables of the Californians." The same immenso herds existed here also. From 120 bushels of wheat sown without ploughing in 1827 over 7000 bushels were harvested.

Mission of La Purissima, eighteen leagues south of the last. "Its lands covered thirteen hundred square miles. . . . The horses were celebrated for their beauty and speed." In nearly all respects this was like those previously described.

Mission of Santa Inez ; seven leagues further southward. It had vast herds of cattle, sheep, and horses. "Its property in 1823 was valued at $800,000."

Mission of Santa Barbara, near the town of Santa Barbara (lat. 34° 30′). This is still preserved ; grapes, olives, and figs are cultivated with great success. In 1852

the county of Santa Barbara returned 137 bushels of olives, five tons of table grapes, 46 barrels of wine, 837 bushels of pears, &c.

Mission of San Buenaventura, nine leagues farther south, and near the sea. In 1825 it had 37,000 head of cattle, 1900 horses, 500 mules, 30,000 sheep, &c.; a thrifty orchard, two rich vineyards, and great wealth in goods and specie.

Mission of San Fernando, sixteen leagues still southward. It has always been celebrated for the superior quality of the brandy distilled from its grapes. Its vineyards yielded annually 2000 gallons of brandy, and as many of wine. "Gold was found here three or four years previous to that on the American Fork."

Mission of San Gabriel, near Los Angeles (lat. 34°). "In its gardens bloomed oranges, citrons, limes, apples, pears, peaches, pomegranates, figs and grapes in great abundance." There was made annually from four to six hundred barrels of wine, and two hundred of brandy. Its herds were as great as those of the northern missions. Los Angeles county, in 1850, returned 57,355 gallons of wine.

Mission of San Juan Capistrano, in the same vicinity, was founded in 1776, and for many years one of the most opulent. It was like the last.

Mission of San Luis Rey. This is near the sea, lat. 33° 13′. It is still in partial preservation. Grapes, peaches, oranges, &c., flourish in great luxuriance. In 1826 it had immense herds; three thousand Indians being attached to it. A military post existed here in 1850, at which observations of temperature were taken. Three months, July to September, had each a mean of 73° nearly, and the mean for December was 50°.6.

Mission of San Diego. This is near the town of San Diego, and was founded in 1769,—the first in Alta California. It was equally successful with the others, but it is now in ruins.

There were several others not named by Mr. Colton,—one the Mission of San Rafael, some miles northwest of San Francisco,—but these are the chief, as named in order from San Francisco to San Diego. Their magnificent herds, with horses of Arabian beauty and endurance; their rich fruits, which are almost tropical at the south; their extraordinary and almost incredible harvests of grain, all speak forcibly of the climatological capacity of the country. With such immense herds the grazing must be far superior to that of Spain, and a *freshness* is inferred, which appears to be a characteristic of all this coast climate. At the same time the fine fruits appear to be particularly favored, and it is only necessary to plant them to reproduce the richest scenes of Spain, if not of Italy.*

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* Mr. Colton's graphic sketch of the general character of these Mission settlements may be valuable here in explanation. "The Missions of California are the most prominent feature of her history. They were established to propagate the Roman faith, and to extend the domain of the Spanish Crown. They contemplated the conversion of the untutored natives, and the permanent possession of the soil. They were the extension of the same system which, half a century previous, had achieved such signal triumphs on the peninsula and through the northern provinces of Mexico. The founders were men of unwearied zeal and heroic action, their enterprise, fortitude, and unshaken purpose might rouse all the slumbering strings of the religious minstrels.

In Alta California these missions formed a cordon the entire extent of coast. They were reared at intervals of twelve or fourteen leagues in all the great fertile valleys

A point of practical importance in regard to the winter rains at San Francisco and southward, ought not to be passed over here. It is that they are not certain to return at the same time or in the same measure every year, though similar when they do occur. They are sometimes much later or much earlier than their average, and sometimes in great excess as well as in great deficiency. The winter of 1849–50 is said to have been one of excessive rain at San Francisco; that of 1850–1 was dry, and of 1852–3 had profuse rains. The last two rainy seasons had 7.3 inches, and 33.5 inches of water respectively; a difference of 26.2 inches.* Colton remarks the effect of this irregularity on cultivation—

"Some of the largest crops that ever rewarded the toil of the husbandman have been gathered in California; and yet those very localities, owing to a slender fall of winter rains, have next season disappointed the hopes of the cultivator. The farmer can never be certain of an abundant harvest till he is able to supply this deficiency of rain by irrigation."

This irregularity of the winter rains is often severely felt in the mining districts, where the absence of water prevents the washing of the auriferous earth. It is a peculiar instance of periodical phenomena putting on non-periodic forms, or becoming non-periodic in a general sense. Both the extreme periods of beginning and cessation are well fixed in the average of years, as well as the intermediate period of suspension, or the division into "early and latter rains," elsewhere alluded to; but in particular cases they vary largely in both time and degree, or amount of rain. February is usually dry, but it was continuously rainy in 1854; in the three previous years the average quantity was half an inch of rain, but in this year 8.4 inches.

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opening to the sea. The first was founded in 1769; others followed fast, and before the close of the century the whole twenty were in effective operation. Each establishment contained within itself the elements of strength and the sources of its aggrandizement. It embraced a massive church, garnished with costly plate; dwellings, storehouses, and workshops, suited to the wants of a growing colony; broad lands, encircling meadows, forests, streams, orchards, and cultured fields; and above all a faith that could take up whole tribes of savages, dazzling them with the symbols of religion, and impressing them with the conviction that submission to the padres was obedience to God.

These vast establishments absorbed the lands, capital, and business of the country; shut out emigration, suppressed enterprise, and moulded every interest into an implement of ecclesiastical sway. In 1833 the supreme government of Mexico issued a decree which converted them into civil institutions subject to the control of the State. The consequence was that the padres lost their power and with that departed the enterprise and wealth of the establishments. The civil administrators plundered them of their stock, the governors granted to favorites sections of their lands, till, with a few exceptions, only the huge buildings remain."

* Dr. Gibbons, Am. Jour. Sci., 1856.

"It is a striking feature of the winter of California that when the weather puts on its rainy habit, the rain continues every day for an indefinite period; and when it ceases there is an entire absence of mist for a long time." (Dr. Gibbons.)

The temperature of this coast is variable in the same manner as just described in respect to rains. The changes belong to unusually long periods when it does change, and whole months are sometimes affected in this general way. December 1850, January 1854, and December 1855, were conspicuously cold winter months. This is characteristic of the whole coast so far as known, though the changes are much less at San Diego than at San Francisco, and they doubtless continue to diminish toward the tropics. At San Diego for six years the extreme mean temperatures for January differ but 3°.6, and for December but 4°.8. At San Francisco by Dr. Gibbons' record January varies in five years 5°.3, and December in four years 6°.6. Benicia, a military post near San Francisco, and one more carefully observed than the military post at San Francisco, gives a range of 6°.9 for January in six years, and of 3°.5 for December. To show how small these measures are as a whole, however, those at Fort Snelling may be given; which, in 35 years, are 28° for January and 28°.2 for December. At Baltimore, January has 14°.2 of range; at Norfolk the same month has 16°.8. At Baltimore, December has 18°.5 of range, and at Norfolk 22°.8. Though the periods are much less on the Pacific coast, six years could hardly be taken here which would not give a range three times as great, at least, as that experienced at San Francisco and San Diego.

VII. GENERAL COMPARISON OF THE TEMPERATE CLIMATES, AND OF THE EASTERN UNITED STATES WITH THE WEST OF EUROPE.

There is scarcely a limit to the citation of illustrative facts in the comparison of climate, and there can now be no better mode adopted for defining the most positive features, since even the observations of temperature are artificial, requiring comparisons to bring out their significance. If the hypothesis of the natural comparability of the corresponding continental positions of the Northern Hemisphere is sound, the specific comparison of the several areas is the best mode of analyzing their respective climates. There are points, also, which cannot now be placed in any one division, yet they may be so placed at a future time, and by citing all that appears of sufficient interest in the whole of the two continental areas, some more definite use of the material may subsequently be made.

The controlling climatological agencies are so disposed that the contrasted sides of the continents are in juxtaposition, and a constant effort is required to remove the impression that there is a radical difference between them. It is necessary to include the whole of both in one view in order to properly understand either, and the farther the illustration and citation is carried the more clearly this necessity appears.

The west of Europe is the most fertile and habitable area of the eastern continent, and the best adapted to occupation by nations of common interests and constant communication. The Asiatic and African climates present abrupt transitions, and strong natural barriers which have been insurmountable heretofore. It is of little importance under our own advanced state, and with the processes of commercial intercourse now perfected, whether the new areas of this continent are Asiatic in their diversity of climates or not; but it is undoubtedly true that climate has had as much to do in giving Europe the central position in advancement, as any, or all other causes; and particularly as great an influence as physical geography, to which the distinctions of this sort are usually assigned. It is a marked distinction in physical

geography that this great area has but a very limited representation in North America, and that it is only on the narrow line of coast beyond the Rocky Mountains at the north, and beyond the coast ranges south of the 47th parallel, that like conditions exist here. This space is not a tenth of that made up by the great plain of the north of Europe, with the British Islands. It is, however, a district of the highest value, if only to the great commercial interests soon to be established on the west side of the continent; and as an outlet to the interior in that direction, it is valuable beyond its merely local area. The best and greatest portion of Europe is thus thrown into comparison with an almost unknown and unoccupied part of this continent.

Humboldt states the climatological position of Europe relative to Asia and America very forcibly as follows: (Essay on Isothermal Lines)

"The whole of Europe compared with America and Asia has an insular climate, and upon the same isothermal line the summer becomes warmer and the winter colder as we advance from the meridian of Mont Blanc toward the east or west. Europe may be considered as the western prolongation of the old continent, and the west parts of all continents are not only warmer at all latitudes than the eastern parts, but even in the zones of equal annual temperatures the winters are more rigorous and the summers hotter on the east coasts than on the west coasts of the two continents. The north part of China like the Atlantic region of the United States exhibits seasons strongly contrasted; while the coasts of New California and the embouchure of the Columbia have winters and summers almost equally temperate. The meteorological constitution of these countries of the northwest resembles that of Europe as far as 50° or 52° of latitude."

"In comparing the two systems of climates—the concave and convex summits of the same isothermal lines,—we find at New York the summer of Rome, and the winter of Copenhagen, at Quebec the summer of Paris and the winter of St. Petersburg. At Pekin, also, where the mean temperature of the year is that of the coasts of Brittany, the scorching heats of summer are greater than at Cairo, and the winters as rigorous as at Upsal. So also the same summer temperature prevails at Moscow in the centre of Russia as towards the mouth of the Loire, notwithstanding a difference of eleven degrees of latitude; a fact that strikingly illustrates the effect of the earth's radiation on a vast continent deprived of mountains."

"This analogy between the east coasts of Asia and America sufficiently proves that the inequalities of the seasons depend on the prolongation and enlargement of continents toward the pole; on the size of seas in relation to their coasts; and on the frequency of northwest winds; and not on the proximity of some plateau or elevation of adjacent lands. The great table lands of Asia do not go beyond 52° N. lat., and in the interior of the new continent all the immense basin bounded by the Alleghany Range and the Rocky Mountains is not more than 650 to 920 feet above the sea."

The intervention of the lofty plateau and mountain ranges of the Rocky Mountains from the 35th to the 50th parallel, which was hardly a received fact of physical geography at the time this was written, is now seen to have no influence on these general points, and to control

the climate of that immediate district only. The insular climate at the coast in America is also as decided as in Europe, and both Vancouver's Island and Sitka—the last at 57° of latitude—correspond with points of like latitude and position in the west of Europe.

The identity of the two west coasts in regard to climate may require the citation of some statistics in this connection, to establish it. In latitude there is little difference between the southwest of England and Vancouver's Island, and the correspondence of climate is quite decided. Though we have no instrumental observation at the last point, we are informed by navigators that there is little frost in winter, and that vegetation advances rapidly in February and March. The whole climate, indeed, is peculiarly soft, equable, and *English.* It is such on the coast of Oregon and California as has been described, and particularly at Sitka, and the upper intervening islands. In the statistics the same low curve of differences among the months, and the same low range of variation for the day belong to both.

Glaisher's corrected result of sixty-five years' observation at London gives the following measures which, in connection with the differences for the short periods observed on the western coast, will establish the point here taken. The differences begin with that from January to February, and they are taken for each month in comparison with the preceding month:

	London, 65 yrs.	Paris, 39 yrs.	Sitka, 12 yrs.	Steilacoom, 6 yrs.	Fort Ross. 4 yrs.
	°	°	°	°	°
Jan.	37.2	35.4	35.7	38.7	47.2
Feb.	+2.9	+4.1	+0.6	+1.9	+0.8
Mch.	+2.4	+4.5	+3.4	+2.3	+1.9
Apl.	+4.4	+5.7	+5.4	+6.0	+1.4
May	+6.6	+8.4	+3.7	+6.9	+4.0
June	+5.2	+4.6	+6.1	+4.8	+1.6
July	+3.7	+2.9	+3.6	+3.6	+1.0
Aug.	—0.3	—0.3	+0.5	—0.4	+0.5
Sept.	—4.6	—5.2	—5.1	—6.1	—2.4
Oct.	—6.8	—7.9	—7.4	—5.4	—2.6
Nov.	—6.7	—8.1	—5.7	—7.3	—2.5
Dec.	—3.6	—5.6	—6.3	—5.7	—2.0

These differences are all very small compared with those of other parts of either continent; the average ascending difference being 4°.2 for each month at London, and 4°.4 at Steilacoom, the most nearly corresponding American position. At Paris this average is 5°; at Sitka 3°.8, and at Fort Ross only 1°.8. All the stations near San Francisco are exceptional, because of the extraordinary coast wind which prevails there in summer. The same average of the six ascending differences among the months is 9°.5 at Quebec, and 8°. at Albany;

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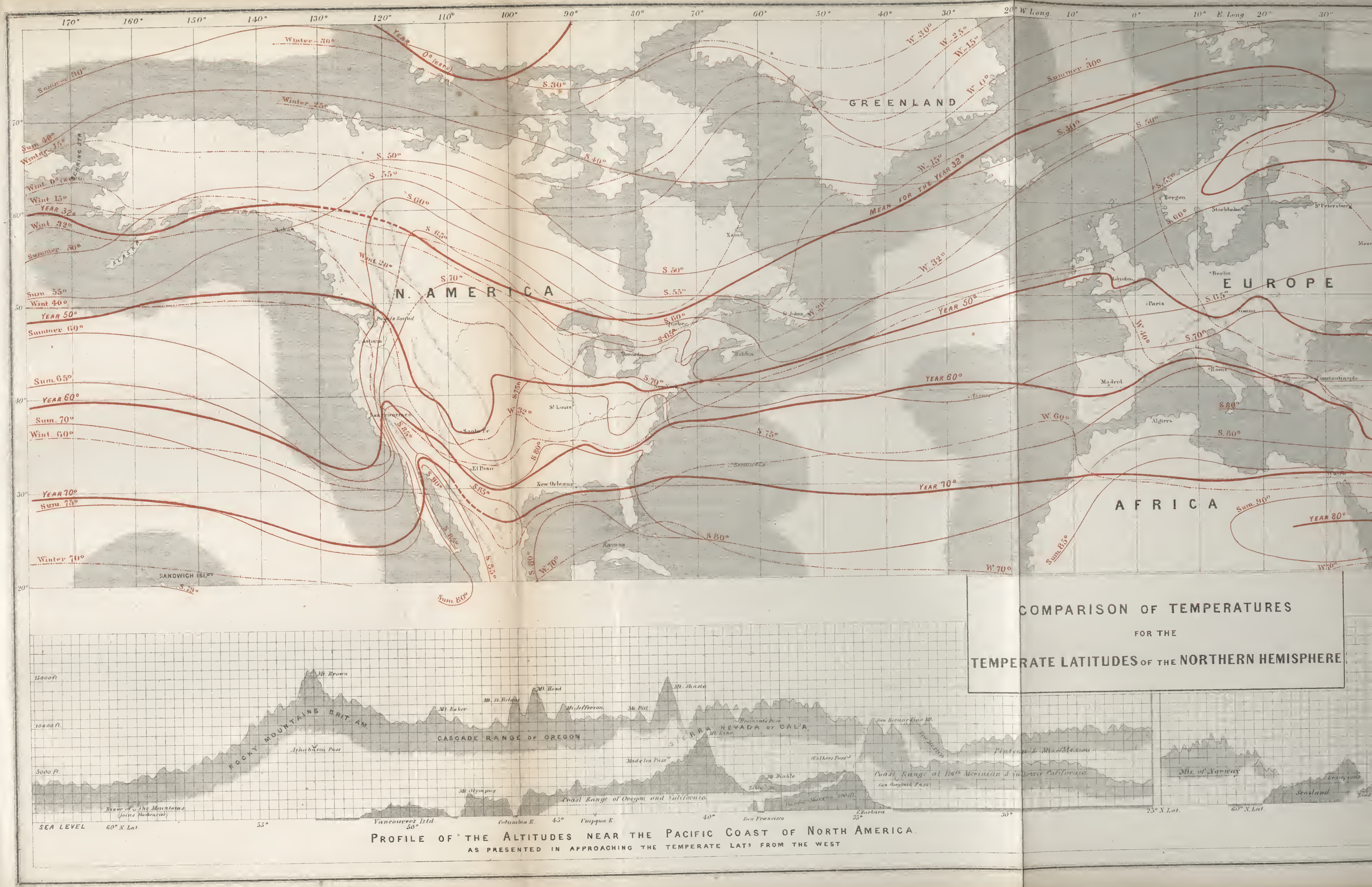
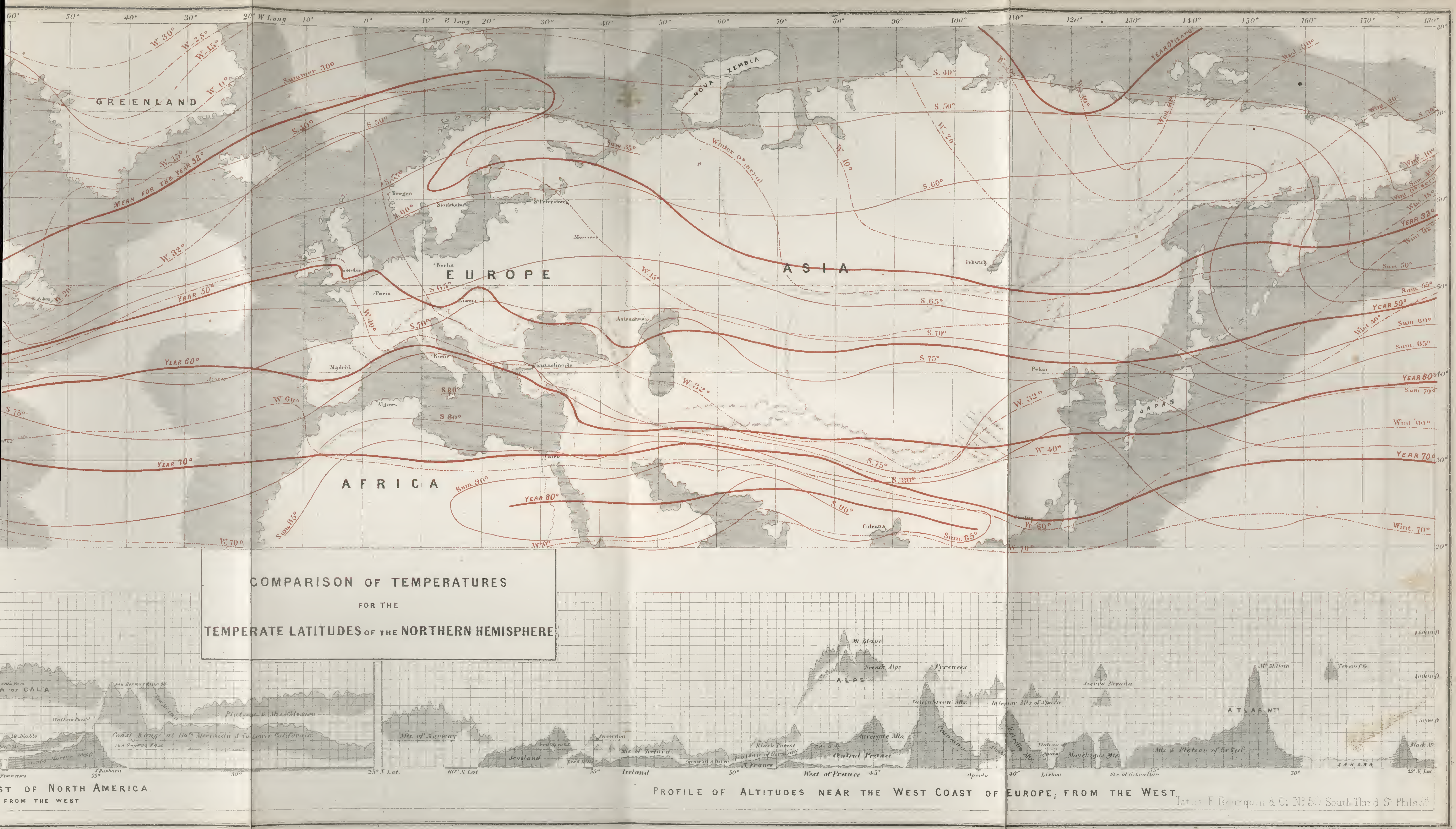
notwithstanding the fact that the first two months differ very little, and June and July also very little. The citation might be indefinitely extended with the same result, proving the correspondence in this respect to be between the two western coasts alone.

Before going further with this notice of the western coasts, a general comparison of the temperature and humidity as illustrated by the charts is necessary, reserving for the last some practical illustrations of the countries we have long considered the representatives of each continent.

The thermal chart comparing the two, has one line of annual means which is confined to the old world, and which does not appear here at all,—that of 80°. Its average position is at 25° north latitude, traversing the deserts from an unknown point of the Sahara to eastern India, where it is at 22° north latitude, nearly. It is possible that some localities have a mean for the year of 75° in lower Sonora and on the east coast of Mexico, but the most southern points north of the tropic yet observed do not attain this degree. Cuba and Key West, however, with a part of the lower peninsula of Florida attain a mean of 75° for the year, a difference which is due to their higher winter temperature. The isothermal of 70° for the year is nearly on the parallel of 30°,—rising above it at the Gulf of California, and falling below in the interior and in Texas, it follows the northern coast of the Gulf of Mexico and crosses the Atlantic and Africa nearly in a straight line. It bends north at the head of the Red Sea and across the deserts until it strikes the Himalayas, from which point it turns southward, and is below the tropic at Canton. Off the west coast of California it falls nearly as low—its general course being in a right line along the 30th parallel, from which it is abruptly turned southward in approaching Canton from the west, and in leaving the California coast. The last curvature is due to the now well known mass of cold water off that coast, and at the east of Asia it is apparently a merely continental effect, which would have been felt here if the continent had occupied the place of the Gulf of Mexico. It is a little remarkable that the average position of this line is farther north in the new than the old world.

The next isothermal in this scale, or that of 60° for the year, falls much farther north in the old world than here, though if its circuit about the northern shore of the Mediterranean were out of the account, the average of positions would not differ. It touches very nearly to the 40th parallel in California, though it falls again to the 30th in New Mexico because of the elevation; the average here would be near the 35th, and it has this position also for the whole distance from the eastern shore of the Mediterranean to the coast of China.


COMPARISON OF TEMPERATURES
FOR THE
TEMPERATE LATITUDES OF THE NORTHERN HEMISPHERE
N. AMERICA
GREENLAND
EUROPE
AFRICA
MEAN FOR THE YEAR 32°
YEAR 50°
YEAR 60°
YEAR 70°
YEAR 80°
SANDWICH ISL^{DS}
ALASKA
CASCADE RANGE OF OREGON
ROCKY MOUNTAINS BRIT. AM.
SIERRA NEVADA OF CAL^{A}
Coast Range of Oregon and California
Mts. of Norway
Scotland
SEA LEVEL
PROFILE OF THE ALTITUDES NEAR THE PACIFIC COAST OF NORTH AMERICA
AS PRESENTED IN APPROACHING THE TEMPERATE LAT^{S} FROM THE WEST


COMPARISON OF TEMPERATURES
FOR THE
TEMPERATE LATITUDES OF THE NORTHERN HEMISPHERE
GREENLAND
EUROPE
ASIA
AFRICA
NOVA ZEMBLA
JAPAN
MEAN FOR THE YEAR 32°
YEAR 50°
YEAR 60°
YEAR 70°
YEAR 80°
Summer 30°
Winter 0° (zero)
London
Paris
Berlin
Vienna
Rome
Madrid
Algiers
Cairo
Constantinople
Astrachan
Moscow
St Petersburg
Stockholm
Bergen
Irkutsk
Pekin
Calcutta
St Johns
Mt. Blanc
French Alps
ALPS
Pyrenees
Sierra Nevada
Cantabrian Mts
Interior Mts of Spain
ATLAS MTS
Mts of Norway
Scotland
Snowdon
Ireland
Central France
Auvergne Mts
Black Forest
Cornwall & Devon
Lisbon
Oporto
Str of Gibraltar
SAHARA
Teneriffe
Plateau & Mts of Mexico
Coast Range at 116th Meridian & Interior California
San Bernardino Mt.
Walkers Pass
Mt. Diablo
San Francisco
S. Barbara
ST OF NORTH AMERICA
FROM THE WEST
PROFILE OF ALTITUDES NEAR THE WEST COAST OF EUROPE, FROM THE WEST
West of France
15000 ft
10000 ft
5000 ft
Lith. F. Bourquin & Co. No. 50 South Third St. Phila.

The position of the line in Europe is north of the 40th parallel, marking there the great increase of temperature due to the African deserts and the Mediterranean Sea.

The isothermal of 50° is as high in America as in Europe and Asia on the whole;—on the west coast of America it goes to 52° of latitude, and to the same point in the British Islands; from these eastward in each case it descends far south—in America because of the Rocky Mountain plateau, returning on the plains some distance above the 40th parallel, and leaving the continent at New York a little above it. The line crosses from England diagonally through central Europe to Odessa, from which point it goes nearly east across the Black Sea, and the Caspian and other basins, but it falls off in approaching Pekin, and leaves the Asiatic continent nearly in the latitude of New York. Its average position is higher by nearly 2° of latitude in Europe and Asia, though if our interior altitudes were removed it would differ much less, and very little indeed from its position on the eastern continent as a whole.

The isothermal of 32° is placed at nearly the same latitude on each continent;—removing the effect of the Gulf Stream on the immediate coast of Norway, and at sea in the Gulf Stream between Spitzbergen and Iceland, the maximum point of the line on the continent would not exceed a degree farther north on the continent of Europe, and the minimum or most southern point would be still nearer to the like position in the United States. The curves are strikingly alike, as drawn from the actual observations.

To sum up this comparison the Eastern Continent has the desert line of 80° which this has not; the isothermal of 70° is in the same position in each; that of 60° the same in Asia that it is in America, but in Europe it is 5° of latitude farther north; that of 50° is more nearly alike on each, yet five degrees of latitude farther north in Europe than in the Eastern States, and on the whole half or three-fourths of a degree of latitude higher in the old world; and the isothermal of 32° is in very nearly the same position, except at the west coasts and islands of Europe immediately influenced by the Gulf Stream. In each case the contrast of position apparent between the west of Europe and the Eastern United States nearly disappears as between the two continents, and they are shown to be similar though not equal in their distribution of temperature; that is, while the Eastern Continent is on the whole the warmest, and has its isothermals most widely separated over the middle latitudes, the same laws of distribution and the same symmetry belong to each.

These remarks, in general terms, apply equally to the distribution of temperature and the isothermals for the seasons. On the chart

for the temperate latitudes, they are drawn for summer and winter, and the intermediate seasons disclose no new law of importance, while these may also be taken for the extreme months with but slight changes of position and these in the form of existing curves. In July the continental excess of temperature would be greater, and in January the continental deficiency or depression of the isothermals greater than for the summer and winter respectively; but for most parts of the surface the position would be only slightly changed to employ each of these seasons as the representation of its extreme month.

In the specific discussion of temperature and the isothermal charts for the United States many points of comparison are referred to, and the absolute positions of the lines need be but briefly noticed here. In summer the mean of 90° touches the head of the Gulf of California here, and probably appears along the west coast of Sonora. In Asia and Africa it lies somewhat lower, and embraces a large area of deserts. Certain districts of the Persian Gulf and Red Sea would probably give this mean temperature at points farther north than those now observed. The mean of 85° for the summer is also farther north here than in the old world; the Salt Lake Desert being as warm as Sahara to the 35th parallel. The summer mean of 80° is also at points farther north here, going to the 39th parallel in the Great Basin, and to the 35th on the plains and near the Mississippi; its most northerly point on the eastern continent is at Sicily, lat. 37° 30′. The mean of 75° is as high here as in Europe, but in approaching the Caspian Sea it is there thrown six degrees of latitude farther north, returning, however, a little below the 40th parallel at Pekin, where it has the same position as at Philadelphia. It is remarkable that, with the general excess of temperature at the East these maximum isothermals should correspond so nearly as they do,—this of 75° being the only one decidedly farther north there, and that only in the low half desert basins of the Caspian and Aral Seas. This last isothermal has, in fact, a gigantic bifurcation skirting the southern border of the great Asiatic plateaus, and if its mean position were taken, the excess would disappear. In Thibet, Upper Persia and Asia Minor the plateaus are so much higher than at the seas before named, and in the desert basin of Western China and Turkistan, that the mean summer temperature is even highest at the north.

The mean of 70° is similarly correspondent in position; as also that of 65°. That of 60° has, however, a large sweep northward in Siberia, while it here goes very little beyond the 62d parallel, and that in a sharp point of prolongation just east of the Rocky Mountains. The lines of 50° and 32° are similarly in excess there; that of 50° being nearly as far north there as that of 32° here;—but all this

is beyond the temperate latitudes. The cool summer of Europe so far reduces the isothermals for that season in the old world that they generally differ less than those of any other season from our own, and the consequences of this uniformity there, are quite important in practical climatology.

In winter the thermal lines differ more, as between the two continents directly, than in summer, generally lying farther north by several degrees of latitude in Europe. The mean of 20° then goes beyond the Arctic circle off the coast of Norway, while here it traverses the great lakes and goes down to the 42d parallel on the plains near the Mississippi, though it again rises to the 60th parallel on the west coast. In Central Asia it falls still lower on the high plains of Tartary, though much affected by the elevation there, probably. The difference of 17° of latitude between its position in the interior of that continent and on the coast of Norway is a striking proof of the necessity of determining all these points from actual observation. The practical difference between the interior at the 60th parallel, when the winter mean is probably 35° below zero, and that near Norway where it is 20° above, is as extreme as may be conceived, and it is impossible to represent it except by lines drawn according to actual observations of the general surface.

Europe and Asia differ as much or more in winter than Europe and North America. The mean of 32° for the winter here falls to the 35th parallel, and in Asia, on the high plateaus of Thibet, nearly to the 30th. In Europe it goes to Ireland, and returns east of the British Islands to the high plateaus of Germany and to the Black Sea at Odessa. There is no point along the west of Europe, even to the extreme point of Scotland, so low in temperature for the winter as Philadelphia, and to find its equivalent it is necessary to go inland to the meridian of Copenhagen and Germany. The contrast diminishes in going southward however, until at the line of 60° for the winter the positions are little different on the two continents, though at the west of Africa there is a considerable curve northward. On that continent the deserts appear to exercise a strong influence in reducing the temperature in winter, and the line of 70° is much lower than at Florida. In this last case the Gulf Stream gives a locally higher temperature to the lower part of that peninsula than is experienced anywhere else in the same latitude;—higher than that of the tropical islands off the coast of China, and higher by a small difference than the Arabian Gulf and Hindostan.

The area which may be said to have a warm winter is very large on the eastern continent, and it embraces the most densely inhabited and valuable portion. A similar area exists here, but it is not so large

positively or relatively, and though now of little interest in the occupation of civilized nations it is certain to attain to a degree of importance proportioned to the activity and necessities of the time. Compared with the average distribution of heat in the northern hemisphere, as we may now determine it, both these areas are anomalous, and that of Europe is particularly so. The *average* of climates for that zone of latitude would give England an inhospitable winter, and all the great plain of Germany and Russia on the west, would be intermediate between its present condition and that of Labrador;—incapable of supporting a dense population, in fact, as the plains of the Volga at the 60th parallel, or as British America east of Lake Winnipeg and Lake Athabasca. Unimportant as the northwest coast of America is in comparison with this seat of empire in Europe now, it is difficult to see any climatological cause of difference. Richardson pronounces the climate at Sitka, lat. 57°, to be practically milder than the west of Europe at the same latitude, and it must necessarily result that many islands and portions of the coast between this point and Puget's Sound will permit a large population. The superior capacity of Vancouver's Island is well known, but of several other islands of considerable size, and of the adjacent coast scarcely anything is known.

Next to this is the region of fruits and vines, south of the 37th parallel on this continent, and embracing all the interior and west coast. The Mediterranean district, and all that lies in its latitudes east to Hindostan, is the parallel portion of the old world. The American district is not dissimilar, and undeveloped as it is, an inadequate appreciation of its capacity exists.

Next, from the European point, are the interior plains of Russia and the north of Germany, which there open to the sea at the west, or at least, are not shut off from it by high mountains. Here the plains of British America and the prairies west of the Mississippi are shut off from the Pacific by lofty ranges of mountains which originate more decided contrasts with the sea climate of the latitude than in Europe, yet they are, as is elsewhere shown, essentially the same. The British American climate is better adapted to occupation for agricultural or other purposes than is generally supposed, and both in capacity and in actual production of native growths, forests, &c., a line southeastward from Fort Liard at the 60th parallel to Lake Winnipeg, is not inferior to a like line from St. Petersburg southeastward.*

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* Richardson remarks that "wheat is grown with profit at Fort Liard, lat. 60° 5′; at Dunvegan, Peace River, lat. 56°; at Fort James, lat. 54° 30′, in a mountainous region at the source of Frazer's River; all these positions being from 500 to 1000 feet above the sea."

The vicinity of St. Petersburg is known to be scarcely cultivable for any grains and wholly unprofitable for wheat, and at Veliki-Oustoug, on the same parallel fifteen degrees of longitude eastward, is found the defined limit of all grains; wheat not going so far, and being uncultivable beyond the Volga. It is clear that the climatological capacity of the northern plains of this continent has been much underrated and greatly misunderstood.

The east side of the continent near Hudson's Bay, and including Labrador, has usually been thought quite anomalous in its extreme low temperature. It so appears from any comparison we can now make, yet very little is known of eastern Siberia from the mouth of the Amoor northward. This point is not so far from correspondence with Quebec as may be thought, and it quite corresponds with the north point of Newfoundland in latitude. Labrador is not more forbidding than Okhotsk and Kamtchatka at points equally removed from sea influence, and there is but a small tract in Kamtchatka where rye and barley may be grown. At Petropaulouski, lat. 53°, the temperature for four years is given at 31°.5 for the spring; 55°.5 for the summer, 37°.5 for autumn, 19° (?) for the winter, and 28°.5* (?) for the year. At Nain, Labrador, lat. 57°10′, the mean of three years is 23°.7 for spring, 48°.6 for summer, 33°.5 for autumn, 0°.4 for winter, and 26°.5 for the year. For the spring, summer, and autumn, the proper correction for the difference of latitude of the two positions would show the general climate to be quite the same as that of corresponding latitudes in North America.

Comparing Hudson's Bay at the 60th parallel with Yakutzk, there is more difference disclosed than in the previous cases; not in the winter cold, but in the summer heat, and the consequent productive capacity. Some small grains may be grown over a considerable tract here, and cattle may be kept, while no sort of cultivation or grazing is possible in most of the country about Hudson's Bay. The advantage in Siberia is in the heat of summer, which is much increased by the general continental agency, acting with less check in Asia than in the vicinity of the immense water surfaces, so long covered with ice, in America. The summer mean at Yakutzk rises to 61°.7, or above that of St. Petersburg, though two degrees of latitude further north, and on the opposite side of the continent. It appears that the land areas of British America are too much covered with water and

* These figures are taken from Lippincott's Gazetteer, where the authority is not named. In which the error is, it is impossible to say, but it appears to be in both the winter and yearly mean. By the best analogy it should be nearly at zero for the winter, and at 32° for the year.

ice, and with soils too heavy and retentive of water to rise in temperature with the advance of the season. There are few instances in which dry or sandy tracts appear, or of the occurrence of the trees and shrubs which these localities would support as the climate now is there—pines, poplars, and other deciduous trees, with the grasses. Yet further west the limiting line of this climate and these productions rises rapidly in latitude quite to the mouth of the Mackenzie, and within the arctic circle.*

"The boundary line of wood takes a diagonal or northwest direction from the 91st meridian, and, before reaching the 120th, has risen to the 67th parallel." (Richardson.)

In these colder plains of the north half of the temperate latitudes there is, on the whole, little preference for the climate of Europe and Siberia. At Mackenzie's river, which is itself interior, we have the cereals as greatly favored as at any point at the same latitude in the old world, except a narrow line of the Norwegian coast, where they are said to go to the 70th parallel; they rise as high on the Mackenzie's as in any part of Russia or Siberia. The local influence of the icy region of Hudson's Bay reduces the cultivable capacity by cooling the summer, while at Yakutzk, on the Lena, a preponderance of dry areas exists, and cultivation and grazing are permitted in a slight degree.

These northern plains of both continents are more directly associated with the interior plains and prairies of the middle latitudes than with any other geographical divisions, and these have already been compared. The plains of the Black Sea and a portion of the Steppes belong to the division, and in Asia they merge, as here, into the saline and arid steppes and deserts by a gradual transition. All are characterized by a warm summer and a cold winter, possessing great capacity for cultivation even when these extremes are very great. Fort Snelling here, and Kasan in Russia, would be very good representatives of the average of these districts. East of Kasan the plain at once becomes uncultivable, and that point is much more nearly at the climatological limit than Fort Snelling is here. The position more directly corresponding here would be on the Saskatchawan river, near

* "In good seasons barley ripens well at Fort Norman at the 65th parallel, and potatoes and other garden vegetables are also raised there. The 65th parallel may therefore be considered the northern limit of the cereals at this meridian; for though in good seasons and in warm sheltered spots a little barley might possibly be reared at Fort Good Hope (67th) the attempts hitherto made there have failed. It takes three months, usually, to ripen on the Mackenzie, and on our arrival at Fort Simpson we found it in full ear, having been sown seventy-five days previously."—*Richardson's Arctic Expedition*. At the same locality, Fort Simpson, a permanently frozen substratum, 6 feet 3 inches in thickness, was found at the depth of 10 feet 7 inches from the surface.

Lake Winnipeg, but there are no reliable averages beyond Fort Snelling in that direction, except at Norway House, which is too far eastward.

		Spring	Summer.	Autumn.	Winter.	Jan.	July.	Diff.
	°	°	°	°	°	°	°	°
Fort Snelling, lat	44.53′ ;	45.6	70.6	45.9	16.1	13.7	73.4	59.7
Kasan, . . "	55.48 ;	36.2	62.4	36.9	6.3	3.5	64.8	61.3
Taganrog, . "	47.12 ;	46.6	70.2	47.8	22.3	20.7	72.1	51.4
Norway House "	54.00 ;	26.2	59.9	30.0	–3.7	–7.0	63.5	70.5

These measures are much alike in the three cases, and with a station here on the plains of the Saskatchawan we should have a very striking reproduction of Kasan. As it is the differences are much the same throughout the whole curve of months, and particularly between summer and winter and between the extreme months.

The distribution of rain is the same in the two cases also. There is very little of rain or snow in winter, and the greatest quantity is in the early part of the summer. In referring to the distribution of rain on this continent some facts are cited from Russian records, and the additional statistics to be found in the tables give the opportunity of further verifying the point.

The interior areas of the two continents have been sufficiently compared, perhaps, in a previous chapter. As in the cases or departments just mentioned there is here a strong general similarity, with specific differences and peculiarities only. Great as the development of continental features of the eastern continent has been held to be, we find no general contrast between the two; and we have found that the humid, half tropical characteristics, referred to by some authors as distinguishing the western continent, belong only to portions which have their full equivalents at the east. The immense area of each division there has, in the absence of observations distributed over the whole, heretofore rendered it difficult to consider any part in its proper relations to the whole area of the continent in which it is found. The two masses of land in the northern hemisphere are symmetrical, and equal, in the more general sense, in their influence as land masses in modifying climate. But as they are not equal in area, the corresponding portions differ in the degree of the characteristic forms.

The last division is that made up of the east of each continent from the tropic northward to the desert areas, or to the cold and barren plains; and this is the first in which the American area has a higher temperature with other peculiarly favorable general conditions. China and the Eastern United States, including the Mississippi valley, are the corresponding areas in this case, and though there is little difference in the absolute surface of the two, the last is relatively, or in compar-

ison with the continent on which it is found, very much the greatest.* The great valley or plain of the Mississippi has no perfect representative in China, though there are immense rivers occupying valleys transverse to the meridians, and opening into the sea at the east. If we were able to compare all points of these valleys of contrasted position, it would be possible to say whether the peculiar climate of the Mississippi valley was due to its opening southward. The river Yang-tse-Kiang, or Kiang-Ku, of China, is really gigantic, and the district which it traverses is marked by almost tropical fertility; lying not far from the 30th parallel, on the average. The next great valley is that of Yellow River,—the Hoang Ho—and in this, at the 34th parallel, the lemon and orange are still grown.†

The botany and productions of China as given by Murray abound in evidence of the parallelism of that climate to that of the United States, and in the absence of temperature records we have no more decisive data for comparison. Canton is within the tropics, but it does not differ largely from Havana and the south of Florida. The district intervening to the 30th parallel is not wholly unlike southern Florida, the delta of the Mississippi and the south of Texas, though doubtless richer than these in actual cultivation and productiveness. The great Yang-tse-Kiang valley would lie parallel to the Gulf coast, and in it the tropical fruits and growths are abundant. Murray says of these—

> "The camphor tree, the chesnut and bamboo (that giant of the grass tribe) grow here together, with the pines, thuja, and cypress, whose dark hues and uniform aspect contrast strikingly with the rich, brilliant, and varied vegetation which surrounds them. . . . Various species of orange, lemon, tea, sugar cane, rice and pomegranate, the black and white mulberries, the vine, walnut, chesnut, apricot and fig are grown on the same spot; but neither the palms, bananas, guava papaw, or other species requiring the continued heat of the tropical regions."

Northward from this river, as from Savannah to Philadelphia, stretches the distance to Pekin; but though there are still great rivers flowing from the north and west of China there are no interior posi-

* The area of China is given at 1,280,000 square miles, (Lippincott's *Gazetteer*) or 1,298,000, (*Murray*) lying between lat. 20° 20′ and 41°; and long. 98° and 123° east. The part of the United States under consideration extends from lat. 25° to 49°, and between the meridians 70° and 105°. According to an estimate of the Topographical Bureau there are 2,170,164 square miles east of the Rocky Mountains, or in the United States not included in the Pacific slope. Of the half desert country bordering the mountains requiring to be thrown out in the present illustration, a portion would be made up from Canada, leaving the area more than 2,000,000 square miles.

† "The orange tree, with the lemon, is still seen at Koue-te-fou, lat. 34° 30′, on the right bank of the Yellow River." (Murray.) Williams, a recent and accurate writer, does not mention the existence of these so far north; in referring to the range of cultivated staples and fruits of tropical origin his notices of these in China will be quoted.

tions analogous to St. Louis and Cincinnati, with the rich river valleys of which these points are but representatives. Scarcely anything is known of the cultivation of this part of China or of its productions, and but for the admirable observations taken now for many years by the Russian Embassy at Pekin, the data for comparison would be wholly wanting. From these we learn that the winter is more severe and the summer warmer than at Philadelphia, the curve of changes for the year being somewhat more sharp and abrupt. But of the country westward of Pekin, which rises considerably, and at a distance equal to that from Philadelphia to Cincinnati, becomes blended with the extensive sands of the Mongolian basin and desert, we can only infer that it would be much colder and more extreme, at least in winter, than the Mississippi valley.

In examining the range of cultivated staples of tropical or semi-tropical origin the products and climate of China will require some additional notice, and what is accessible on this point may be deferred to that place.

From some recent observations the dynamics of climate there are believed to be similar to those of the Eastern United States. Commodore Perry has recently verified the existence of a stream of warm water there quite like the Gulf Stream, and he has observed a general similarity of its great storms to those of the Atlantic along the Gulf Stream.* The distinctive overflow of the great rivers when the

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* The following extracts are made from a paper presented by Lieutenant Bent, U. S. N., of the Japan Expedition, at a meeting of the New York Geographical and Statistical Society, in January, 1856. After defining the equatorial current of warm water from the eastward in which the Japan current has its orgin, he says:

"This offshoot, the Kuro-Siwo or Japan stream, is separated from the parent current by the Bashu Islands and south end of Formosa, in lat. 22° north, long. 122° east, and is deflected along the east coast of Formosa, where its strength and character are as decidedly marked as those of the Gulf Stream on the coast of Florida. This northerly course continues to the parallel of 26° north, where it bears off to the northwest and eastward, washing the whole southeast coast of Japan as far as the straits of Sangar, and increasing in strength as it advances until reaching the chain of islands southward of the Gulf of Yedo, where its maximum velocity, as shown by our observations, is 80 miles per day."

Lieutenant Bent remarks the cold counter current between this and the Chinese and Japanese coasts, the attendant dense fogs, and other striking incidents of the correspondence of the two coasts at 40° of latitude and northward. Referring to the correspondence traced by Redfield and Maury in regard to storms in these latitudes, he says, "I was forcibly struck with these coincidences of recurvation (of the tracks of storms) when the tracks of the Gulf Stream and the Kuro-Siwo together with the paths of the hurricanes were traced upon the same chart."

"The influence of the Kuro-Siwo upon the climate of Japan and the west coast of North America, is, as might be expected, as striking as that of the Gulf Stream on the coasts bordering the North Atlantic. From the insular portions of Japan, with the

storms and tides together act upon the portions near the sea is a fact well known to our commercial interests there, and, though it is difficult to cite positive notices of these features, especially from any instrumental observation, it is not doubted that there are very decisive features of similarity in all these points of climatology. A recent, and apparently very thorough and accurate work,—deficient in statistics of climatological observation, however, as all works must necessarily be now,* refers to the correspondence here indicated in the following terms:

"The average temperature of the whole empire is lower than that of any other country in the same latitude, and the coast is subject to the same extremes as that of the Atlantic States of America. The climate of Pekin is salubrious, though subject to extremes; epidemics are rare, and the plague unknown there, as everywhere else in China. The water is frozen from December to March; in the spring violent storms and whirlwinds occur; the winters of the capital are like those of Stockholm or Boston, ranging from 10° to 25° Fahrenheit; but the summers are those of Naples and Washington, the temperature sometimes rising to 95° and 105°, but more usually from 75° to 90°. Autumn is the most pleasant part of the year, the air is then mild, the sky serene, and the weather calm. It is probable that the position of Pekin, on a wide and poorly sheltered plain at the foot of mountains and of high table land, increases both the heat of summer and the cold of winter. This remark is still more applicable to the towns on the Gulf of Pechele, and Gutzlaff describes in his journal the paralyzing effects of cold upon his shipmates at Kaichan, as depriving them of all energy."

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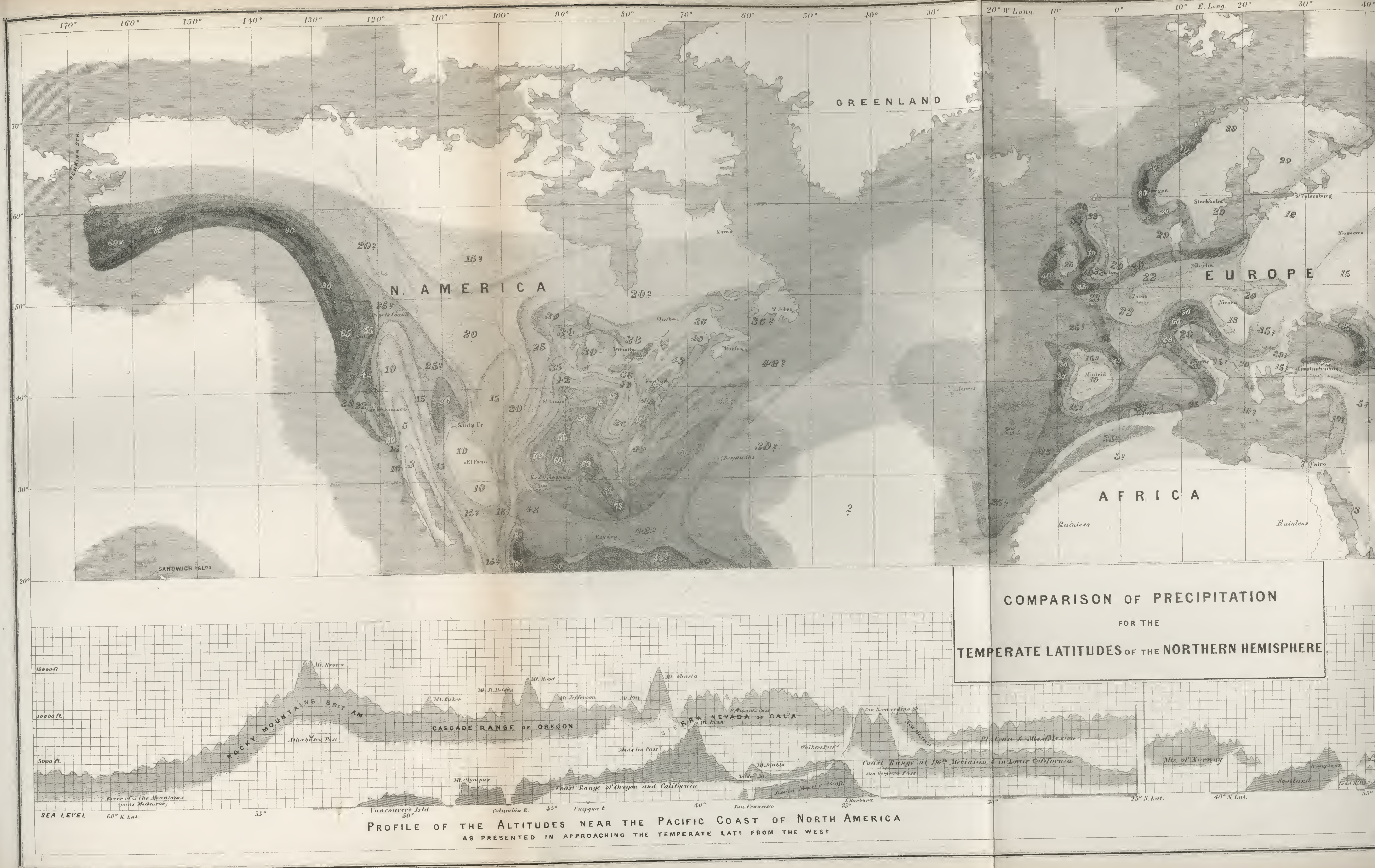
intervening sea between it and the continent of Asia, it has a more equable climate than we enjoy in the United States; and since the counter current of the Kuro-Siwo does not make its appearance on the eastern shore of the islands, south of the Straits of Sangar, and as these islands, in their geographical position, have a more easterly direction than our coast, the Kuro-Siwo, unlike the Gulf Stream, sweeps close along this shore, giving a milder climate to that portion of the empire than is enjoyed in corresponding latitudes in the United States."

"The softening influence of Kuro-Siwo is felt on the coasts of Oregon and California, but in a less degree, perhaps, than that of the Gulf Stream on the coasts of Europe, owing to the greater width of the Pacific Ocean over the Atlantic. Still the winters are so mild at Puget Sound, lat. 48°, that snow rarely falls there, and the inhabitants are never enabled to fill their ice houses for the summer. Vessels trading to Petropaulouski and Kamtchatka when becoming unwieldy from the accumulation of ice on their hulls and rigging run over to a higher latitude on the American coast and thaw out, in the same manner that vessels frozen up on our own coast retreat again into the Gulf Stream until favored by an easterly wind."

"The same atmospheric meteors of revolving storms, or cyclones, prevail on the coasts of China and Japan as those that have been made so painfully familiar to us by their devastations among the West India Islands and along the Atlantic coast. In the passage of the United States steam frigate Mississippi from Simoda, Japan, to the Sandwich Islands, in October 1854, the thermometer disclosed a cold aqueous space between the meridians of 155° east, and 170° west longitude, and the parallels of 30 and 35 degrees of latitude, which bears a general correspondence in the Pacific Ocean to the position of the Sargasso Sea in the Atlantic."

* *Williams' China.*



COMPARISON OF PRECIPITATION FOR THE TEMPERATE LATITUDES OF THE NORTHERN HEMISPHERE

PROFILE OF THE ALTITUDES NEAR THE PACIFIC COAST OF NORTH AMERICA AS PRESENTED IN APPROACHING THE TEMPERATE LATS FROM THE WEST

COMPARISON OF PRECIPITATION FOR THE TEMPERATE LATITUDES OF THE NORTHERN HEMISPHERE

The same writer refers to the fact that "northeasterly gales are common in the spring and autumn, and often continue to blow for three days" at points along the east coast from Canton to Pekin. The typhoons of the seaboard are clearly similar to the storms of the Gulf Stream, as before remarked, and their intensity and narrow limit in the lower latitudes, spreading as they progress northward, is remarked in the notices given by Williams. As an instance of the changes and extremes the same authority mentions the fall of snow, nearly two inches deep, at Canton in February, 1835, which remained on the ground three hours;

"But it was such an unusual event that the citizens hardly knew what was its proper name, some calling it falling cotton, and every one endeavoring to procure it as a febrifuge." "At Canton the highest recorded temperature in 1831 was 94°, in July, and the lowest 29° in January."

A parallel phenomenon here would be a fall of snow at Key West or Havana, of which there is as yet no instance.

The monsoons of India, and of all the tropical latitudes and borders of Asia, exist to some extent at Canton, but their characteristics disappear entirely before attaining the 25th parallel, and the non-periodic character of all the phenomena is there the same as on the eastern coast of the United States.

In an early chapter some of the distinguishing features of the eastern United States were enumerated as preliminary to an analysis of the climatology of the whole continent in temperate latitudes, and it was then, as in several other instances, in part explained by European or Asiatic citations. It is impossible to perfect any explanation otherwise, or to define conditions intelligibly and forcibly without drawing parallels with others which are known and capable of being recognized as either similar or contrasted. It appears necessary in closing the general comparison of the temperate latitudes of the two continents to review the relation of these contrasted sides in regard to the points of most frequent interest, and in the tone in which we are accustomed to compare them for practical purposes.

From Europe as a standard the American climate is singularly extreme both in temperature, humidity, quantity of rain, winds and cloudiness or sensible humidity. The oscillations of the conditions is greater, and they vibrate through long measures above and below the averages. All the irregular as well as regular changes are of this sort, and the European observer defines the climate as directly antagonistic to that he has left. At New York, with a maritime exposure, and in the sphere of the local influence of the city, the mean monthly range of temperature as observed for thirty years is 38°,—the highest observation for each month of the same name in this period differing from the lowest by this measure, for the average of years. The inadequacy of the hours to represent the actual extremes would without doubt increase this number to 43°, which may be taken as the mean monthly range at maritime exposures in the latitude of New York. This range increases northward and toward the interior, and it is no less at Charleston. It exceeds 50° at Fort Snelling, and is nearly 50° at St. Louis. The extreme range in the period of thirty years at New York

averages over 60° for each month; the absolute maxima and minima for this period are as follows:

	New York, Fort Columbus. 33 years.			Washington, Lt. Gilliss. 4 years.		
	Max.	Min.	Diff. of Range.	Max.	Min.	Range.
Jan.	60°	—2°	62°	66°	—4°	70°
Feb.	68	0	68	70	—5	75
Mch.	78	3	75	82	15	67
Apl.	84	20	64	91	29	62
May	92	32	60	96	34	62
June	98	42	56	97	45	52
July	104	52	52	103	56	47
Aug.	98	52	46	99	52	47
Sep.	92	39	53	90	33	57
Oct.	86	29	57	82	22	60
Nov.	71	12	59	74	12	62
Dec.	69	—3	72	60	1	59
Year	103	—3	107	103	—5	108

At Plaistow, near London, Howard gives the extreme for 25 years as 97° for July and —5° for January,—range for the year 102°.

At New York the thermometer was not self-registering, and the hours were 7 A. M. and 2 P. M. to 1842, and *sunrise* and 3 P. M. subsequently; the difference of these from the registered extremes would be five degrees in the range, or difference,—two and a half on each extreme. The same hours were observed at the other American stations named, except at Washington, where a register thermometer was observed, and the period is four years. The observations of Howard are at Plaistow, near London, and to compare fairly with New York a point observed in the New York University system should be taken, North Salem, which would be not so far from the sea as Plaistow. For twenty years at this point the absolute extremes are 102° and —18°, the range 120°, or 13° greater than that observed at Fort Columbus. No list of monthly extremes is given by Howard, and it would be difficult to extract them from his tables, but he gives a list of extremes for each year which may be useful for reference.

Yearly extremes of Temperature, observed mainly at Plaistow, near London.

	Max.	Min.	Range.		Max.	Min.	Range.
1807	87°	13°	74°	1820	91°	0°	91°
1808	96	12	84	1821	81	18	63
1809	82	18	64	1822	92	14	78
1810	85	10	75	1823	82	4	78
1811	88	14	74	1824	88	19	69
1812	78	18	60	1825	97	21	76
1813	85	19	66	1826	92	14	78
1814	91	8	83	1827	89	10	79
1815	80	17	63	1828	89	24	65
1816	81	—5	86	1829	81	16	65
1817	86	17	69	1830	90	8	82
1818	93	16	77	1831	87	18	69
1819	86	10	76				

It will be seen that though the range for the whole period is great, and near to that observed at New York, the range for *each year* is far less; only eight out of twenty-five years attaining to 90°, and only two falling to zero. At New York by the imperfect observation of the minima, seven years of thirty-three fall to zero or below it; at North Salem every year of twenty does, and the mean is 9°.5 below zero. At Washington eight years of twenty-four fall below zero, only seven of the twenty-four being observed by the register thermometer. The dates in the last case are from 1823 to 1842, and from 1852 to 1856.

The *average* range for the 25 years near London is 74° as derived from the above table; the average range for 20 years at North Salem near New York is 105°; at New York city for 33 years 88°.9; at Washington for 22 years 92°. At all the American stations the register thermometer would give a greater range, and at the interior posts much greater. At Albany, for 25 years, the mean range is 105°. Thus the oscillations of the English climate are not constant as they are here, though extreme at remote intervals—we have, also, compared the point of greatest range in England with one of the most decided maritime and equable character here, for its latitude. The tables of extremes of temperature will enable any one to extend this comparison.

Similar contrasts occur in the quantity of rain falling in a month, but one less decided, if it exists at all, in the range of atmospheric pressure as shown by the barometer. In regard to both temperature and the quantity of rain the range for the irregular changes is comparable with that of the successive months, and with the quantities for the month;—where the average rain fall is great the differences are great, and where the differences in the annual curve of temperature among the months are great the non-periodic changes are equally extreme.

It is shown by the comparison as a whole that Europe is far from being the representation of the average climates of the temperate zone, and that all deductions and comparisons based on that view mislead more or less. It is equable, while this is extreme in the reverse character; though not a continental climate, strictly, on the Atlantic coast. In regard to many features connected with irregular disturbances and changes, there is as great a contrast between England and New York as between either and the most desert-like areas of the interior at the Great Basin, or in Central Asia. All the forces set in action by the precipitation of moisture culminate at the eastern sides of the continents, and there produce the great oscillations which attend and which constitute great storms. It is true that these are felt at the western coasts of Europe, and sometimes as very great disturbances, but they do not occur as the regular or constant order of the phenomena, nor are they attended with sharp extremes of temperatures, at least. The proximity of the heated mass of waters constituting the Gulf Stream intensifies all the phenomena of disturbance even along the coast, and the peculiar storms of greatest severity from Florida to Newfoundland show the effects of this agency, as an addition to the cause which may be designated as a continental one.

These great storms in many cases occur in England and France during the colder months, but at distant intervals, and as exceptional cases. The same is true of the Pacific coast of North America, where the sweep of changes of this sort appears to strike across the great ocean surface from the coasts of Japan, nearly as often as from our Gulf Stream to the coast of France. On the Pacific coast these are never attended with the order and succession of winds which attend them here, and generally in Europe, yet the barometric depression at distant intervals is a marked and prolonged one, sufficiently defining them as of this general character, and as coming from a distance.

A recent Essay on the British climate by Mr. Whitley* presents very forcibly the leading peculiarities there as contrasted with those of the American States, and some quotations from this essay, or briefs of its views, may best serve to illustrate the matter in hand.

Mr. Whitley remarks the slight difference in the mean temperature of all places on the coasts of the British Islands, whether they differ in latitude only, or are on oppo-

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* *Essay on the British Climate, and its Effects on Cultivation*, by Nicholas Whitley, Surveyor, Truro; a Prize Essay for the Journal of the Royal Agricultural Society of England; published also in vol. 1 of the Journal of the Bath and West of England Agricultural Soc., 1854.

site sides of the islands ; on a coast line over two thousand miles in extent, and of which the extreme temperatures are found at Penzance and Aberdeen, there is but a variation of 4° in the annual mean—Penzance having a mean of 51°.8 and Aberdeen of 49°.1. The month of January is warmer in the north of Scotland than in the country round London ;—at Greenwich and Chiswick it is 36° to 37°, but at Wick (Islands of the west coast of Scotland) it is at 38°.5, at the Orkneys 39°.5, and at Shetland 40°. The intermediate points confirm this fact, and Liverpool is at 4° above Boston in winter, which last position, in the interior and near the east coast, has the lowest temperatures at that season on the island.

" The distribution of heat here is less affected by latitude than anywhere else in the world. The zone of 41° to 50° of mean temperature is but 300 miles wide in the eastern United States, while in England it is 1100 miles wide."—Taking positions of full maritime exposure, which greatly increase the distance over those inland, and we have but a slight qualification of this statement of Mr. Whitley for the United States coast ; at Newport, lat. 41° 30′, the mean temperature is just 50°, and at Albion Mines, Nova Scotia, lat. 45° 30′, it is 42°. It cannot exceed 41° at the 46th parallel, or the difference referred to occurs in a space of 4½° of latitude. The following table of mean daily range of temperature, or of the "average differences between the night and the day," is given by Whitley, except the results at Oxford, London, and Plaistow, which are from Radcliffe Observatory, and by Howard (*Climate of London*), at each of the last two stations the mean of ten years is taken, with the minimum temperatures at London diminished by an average of two degrees on account of local influences. After a thorough examination of the relation between the night temperatures at London and at Plaistow, which is three miles northeast of Greenwich Observatory, Howard determined that this correction was necessary to represent the open country of the vicinity.

	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°	°	°	°
Truro, S. W. England ; . . .	6.8	6.7	8.8	12.3	13.4	13.6	11.4	11.8	11.3	10.1	7.9	6 9
Exeter, S. W. England ; . . .	8.6	9.6	12.3	13.5	15.5	15.6	15.1	14 6	13.4	11.4	9.4	7.1
Whitehaven, W. Eng'd ; . . .	8.8	7.6	10.1	12.5	15.4	12.9	11.0	11.0	9.6	7.0	7.5	6.4
Chiswick, near London ; . . .	11.8	12.9	17.0	22.8	23.6	22 8	21.2	21.1	19.4	17.8	14.2	12 7
London and Plaistow, 20 y'rs ;	8.9	10.9	12.8	15.9	17.5	18.6	17.7	17.3	17.0	13.5	10.7	8.7
Plaistow, 6 y'rs, 1817–1823 ; . .	11.2	12.7	15.4	18.9	22.4	24.3	21.7	21.9	19.9	16.3	11.6	11.1
Oxford, Radcliffe Obs'y, 25 y'rs ;	9.9	11.3	15.7	17 9	18.2	16.9	17.2	16.6	17.5	13.6	11.2	9.5
Cambridge, Mass., 4 y'rs ; . .	8.9	8.4	10.3	11.6	14.7	15.7	16.4	14.6	13.8	12.6	10.2	8.5
Washington, 4 y'rs ;	16.7	18.7	19.7	22.7	22.3	18.4	17.4	15.9	19.5	20.5	17.3	16.6
Do. do.	10.3	13.0	14.3	16 5	14.1	14.8	14.9	13.9	14.9	12.6	11.3	8.9
Key West, 1838 ;	6.3	7.7	7.8	7.9	8.1	6.5	8.2	8.8	7.4	6.7	6.3	7.3

Comparison with the stations in the United States can only be made by considering the difference between observations by the register thermometer and the extremes recorded at certain hours. The quantities just given for Washington and those at Key-West are the only ones taken by the register thermometer here, while all the English observations are from that instrument, giving the absolute extremes of each day. At Cambridge the differences are between observations at sunrise and at 3 P. M., and the second series at Washington between 3 A. M. and 3 P. M. It will be seen that these hours differ by an average of five degrees from the averages of the absolute maxima and minima, and adding the differences between the two series at Washington to the series at Cambridge we have a measure of the same character as in the English cases. The American differences are much the largest when made comparable. The record at Chiswick, and the record at Plaistow, appear extreme, and Howard remarks of the last that it appears to belong to extreme years.

At Cambridge the observations are by Prof. W. C. Bond ; at Washington by Lieut. Gillies, at the Naval Observatory ; at Key West by A. Gordon, Esq.

In the annual extremes of temperature there is, as in almost every feature of the

statistics, a greater conformity to the American climate in appearance than in reality; notwithstanding that we compare a high latitude with a low one in placing the British Islands in contrast with the latitudes of New York and Washington. Howard, in his treatise on the Climate of London, gives the single extremes of temperature for each year from 1807 to 1831, which have already been quoted. The years 1808 and 1825 give the highest temperature, and 1816 the lowest of the twenty-five years. It is also true that these are too extreme to represent the climate fairly, and they belong to the exceptional years of long periods in most cases, and are not constant phenomena as in the United States. A reference to the extremes for the year, given in connection with the averages for single years in the United States, will show that the annual range is far greater here, except at stations under local influence, or at maritime exposures.

At Penzance, in Cornwall, the equable character of the English climate is most fully developed, and some facts given of this locality by Mr. Whitley exhibit this character strikingly. Penzance is the garden of the English vegetable markets, producing green peas in May, and by the middle of the month, early potatoes at the same time, the plants having appeared out of the ground in February, and every variety of similar vegetable growths at very early dates. In this respect it is in advance of Norfolk, Penzance being at the 50th parallel, and Norfolk at the 37th. The distance of latitude thus exceeds nine hundred miles between points corresponding in vegetable growths for the three months of spring. In this part of England trees and plants which are natives of tropical climates often remain in the open ground through the winter without injury. Oranges, lemons, myrtles, camelias, magnolias, the Mexican Agave, &c., require no protection from frost, and in sunny exposures are grown in the open air.

Yet these fruits are difficult to ripen under the most favorable circumstances of position, and in the open air generally the apricot and plum produce no fruit; the grape rarely ripens, while currants are acid, and only gooseberries and strawberries attain perfection. The apple, hardy as it appears in the American climate, rarely comes to perfection at positions of the average exposure, and it is only successful in the close, warm vales of South Devon, Hereford, Gloucester, and Worcester.

This contrasted capacity in regard to fruits, and to grasses or succulent vegetables, belongs to all the west of Europe in comparison with the United States; and it is due to the low temperature and humidity of the summer there, in contrast with the high temperature and freedom from sensible moisture here. The damp, foggy atmosphere, with great prevalence of clouds, is there such as to restrict wheat to the central parts and east of England, and in many cases to affect the whole west of Europe by a degree of humidity greatly injurious to grains. Whitley gives the proportion of cloudiness at Truro at near seven-tenths for the winter, five-tenths for spring, near seven-tenths again for summer, and six and a half tenths for autumn. The least cloudy month is May, at two and a half tenths. The Greenwich observations are at very nearly the same measures, May being three-tenths cloudy. For six stations cited by this author the same features appear, and the excess of clouds in summer exists in every case. Even in the east of England the difference is mainly in the altitude of the clouds and in their removal from the low surface stratum they occupy in the west.

In consequence of this equable temperature and great humidity the type of vegetation has a peculiar character, and but few plants of American forms, or of those of the south of Europe appear. The vegetation is like that of Normandy and Brittany, and such as is not found elsewhere, the Germanic type predominating. "All plants universally diffused are German." (Forbes.) The spread of wheat and the better cereals is of recent date in the British Islands, and it is due to the great care and superior cultivation applied. "In 1747 a small field of wheat was a great curiosity at Edinburgh, and up to 1770 very little grew there. Now it is abundant, and goes

north to Murray Frith. In the north of Ireland Mr. Wakefield thought it useless to undertake it, but now it is extensively cultivated there." (Whitley.)

The positive measure of humidity given by Whitley cannot be compared with observations here, unfortunately, and it is impossible to say whether the absolute quantity of moisture contained in the atmosphere there equals or exceeds the quantity here. There is more rain in the United States by a large measure than there, but the amount falls in less time,* and the average of saturation is certainly much less here. When saturated at the high temperatures characteristic of our summers, the air contains an immense quantity of water, however, and on its precipitation the quantity of rain is necessarily very great. Of thirteen stations given by Whitley, the average for January is two and a half grains of vapor in a cubic foot of air, and the quantity regularly increases to the three warmer months, which average nearly five grains each to the cubic foot. For December the average is three grains, and for the year three and a half. As this is not the measure of sensible moisture, the temperature of evaporation or the percentage of saturation must be obtained to give the requisite positive measure. These are not given by the writer quoted, and other evidences must be cited for the comparison. In the west of England a floor of stone is almost always wet from the condensation of atmospheric moisture. Harvest and agricultural implements are often so; in Ireland a wet piece of leather placed in a closed room will not dry in a month. (Arthur Young.)

A decisive point of comparison of the English and American climate exists in the quantity of water naturally evaporated from an exposed water surface. It is a measure of heat and dryness both, and particularly expressive of the sensible conditions affecting convenience and practical life. But it is extremely difficult to procure comparable observations of the quantity evaporated because of the different local conditions of the experiment, in which character the observation is generally undertaken. The following will serve to show the great difference between England and the United States however.

Quantity of Water evaporated—In inches vertical depth.

	Jan.	Feb.	Mch.	Apl.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.		Year.
Whitehaven, England, mean of six years,	0.88	1.04	1.77	2.54	4 15	4.54	4.20	3 40	3.12	1.93	1.32	1.09	=	30.03
Ogdensburg, N. Y. 1 year;	1 65	0.82	2.07	1.63	7.10	6.74	7.79	5.41	7.40	3 95	3.66	1.15	=	49 37
Syracuse, N. Y. 1 year;	0.67	1.48	2.24	3.42	7.31	7.60	9.08	6.85	5.33	3.02	1.33	1.86	=	50 20

Dr. Holyoke in a notice of his extensive observations at Salem, Mass., assigns the annual quantity there at 56 inches. Col. Abert† discusses the English and other authorities, and gives the following estimate for Baltimore.

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* In the fifteenth volume of Reports of the Radcliffe Observatory, Oxford, England, a table is given of the number of days of rain which yielded various quantities from .05 to 1 inch and more. Though for but one year, 1854, it forcibly expresses the proportion of very light rains there. Of 156 days on which rain fell,

73	days gave less than	.05 inch.
30	" " between that and	.1 "
27	" " between	.1 and .2 "
9	" " "	.2 " .3 "
9	" " "	.3 " .4 "
4	" " "	.4 " .5 "
1	gave	.6 "
2	"	.8 "
1	"	1.0 "

It will be seen that four-fifths of the number fall below two-tenths of an inch, and nearly half are less than five hundredths.

† Col. Abert's Report to the Governor of Maryland in regard to the Chesapeake and Ohio Canal, 1839.

By Halley's rule and Brantz' tables of rain fall,			66.48 inches.
" Dalton and Hoyle	and	do.	58.64 "
" M. Cotte (Gauthey)	and	do.	88.64 "

Quoting the quantities given by several authorities for Cambridge, Mass., at 56 inches, Col. Abert assumes for Baltimore an annual average of 6.37 inches monthly for eight months of the year, or 51 inches, considering the remaining portion of the year unnecessary for the calculation in regard to reservoirs, &c.

The first quantity given above, at Whitehaven, England, is reported in *Phil. Trans.* for 1851 by J. F. Miller; it was very carefully observed from 1843 to 1848, the evaporation being from a shallow copper vessel, one and a half inches deep, filled daily and protected from rain. The district is one of the wettest of England, the mean quantity of rain for the same time having been 45.25 inches. Generally in England the quantity evaporated is less than the quantity of rain, while here it is always much greater—in both cases the evaporating vessel being protected from rain. The drainage by rivers is of course the expression of the excess of rain falling over the natural evaporation, and it is estimated at from forty to sixty per cent. of the quantity of rain. At Baltimore Col. Abert assumed the evaporation from a reservoir surface to be to the quantity of rain as 2 to 1 for the summer months.

The point of the present citation is to show the great disparity in the absorbent power or capacity of the air in England and the United States; the air there, under like conditions, taking up but half the quantity evaporated here.

In the Eastern United States there is great irregularity in the quantity of sensible moisture present, and there are often periods of two or three days in duration characterized by excessive saturation. But the average of this condition is very low, and no forms of vegetation indicate its abundance. Forests are free from mosses except at the more elevated points, and for the central States the forms of succulent vegetation are very much restricted, the grasses and other vegetation giving evidence of aridity as the distinguishing feature, and failing to cover the surface with a constant growth. The limit of this permanence of the English grasses without cultivation is about at the 40th parallel, and soon after leaving Philadelphia southward they become sensitive to the aridity of summer, and require careful cultivation. South of the 38th parallel they are difficult of cultivation under any circumstances.

The want of uniformity between English and American modes of observation renders it difficult to compare the statistics which are really requisite on this point. The temperature of evaporation is the most ready and intelligible form, and its differences from the dry thermometer at once express the desired idea. In English observation the valuable element of the absolute weight of vapor in a cubic foot of air is always accessible, but the temperature of evaporation and its differences are rarely deduced. At Washington Lieut. Gillis gives the mean difference between the wet and dry thermometer from March 1841 to June 1842, and from this the quantities for the warmest hour of the day, 3 p. m., may be taken as a representative of the latitude here; a single English series is added:

	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°	°	°	°
3 a. m.	1.70	1.85	2.72	2.37	3.06	3.08	2.07	1.15	2.39	3.32	3.18	3.10
3 a. m.	3.08	4.40	6.47	5.37	7.05	8.03	8.89	5.29	5.63	4.61	4.77	2.03
Daily means	2.30	2.80	4.06	3.47	4.54	4.86	4.30	2.33(?)	3.20	3.51	3.51	2.60
Radcliffe Obs'y, Oxford, Eng. .	1.30	1 70	2.30	3.60	3.20	3.20	3.60	3.90	3.30	2.40	1.80	2.70

This last series is for twenty-five years, closing with 1854, and it gives very reliable averages for that district, which is one of the most favorable and dry of central England. For the year the difference at Oxford is 2°.7 between the wet and dry thermometer for the mean of 25 years, and at Washington, from this single year, 3°.5. A more extended series would show larger differences here.

These are only adequate to show the differences rudely, as a period of three years

or more would be required to give uniformity in the annual curve. But they show in general terms that the differences are large on the average, and they are necessarily much larger at the extremes, because there are so many intervals of complete saturation.

In addition to the ordinary causes of difference in temperature in different years or parts of a year, the special cause of the equable climate of the north of Europe—the Gulf Stream—acts directly to produce some features of variation. The temperature of this ocean mass varies; Col. Sabine found a temperature 3° to 6° above the average in the Atlantic in January, 1822, and to this he attributed the mild winter which followed.* Whitley says that the sea was found very warm in 1845, and that the autumn was then warm, the succeeding January and February being also 6° above the mean temperature. The changes of temperature of the Gulf Stream are to be anticipated as much as those of the temperature of the volume of air returning from the equatorial regions, and their direct effect, as cited here, shows to what agency the equable character and the warm winter of the west of Europe are due. But the range in the mean of like months in a period of years is still great, as the following table by Howard will show:

	Greatest variation of monthly mean temperature at Plaistow near London, for 25 years, 1806 to 1830.	Do. at New York City, Fort Columbus, 33 y'rs, 1822—54.	Do. at Norfolk, Fort Monroe, 30 years.
	°	°	°
Jan.	13 9	12.7	16.8
Feb.	12.3	19.8	21.6
Mch.	11.2	14.3	20.1
Apl.	8.7	9.4	11.8
May	12.0	10.5	10.6
June	9 4	11.5	12.4
July	8.7	11.8	10.3
Aug.	8.9	9.1	8.5
Sep.	9.8	10 2	8.9
Oct.	12.9	16.9	10.2
Nov.	10.2	12 9	14.7
Dec.	12.4	19.1	22.8

All these quantities appear large; and they are equally so in the *average departures from the mean*, or those which may be considered certain to occur in every year. Glaisher has deduced these variations from the entire series of 65 years of observations at London, and their mean is quite the same as that at Fort Columbus for 33 years, as in the three spring months as a sample:

	March.	April.	May.
	°	°	°
London	2.41	2.30	2.08
New York	2.30	2.59	2.06

Some portions of the British possessions in America, embracing Newfoundland and the islands of the Gulf of St. Lawrence, with a part of Nova Scotia, are so far surrounded by the sea as to have a decidedly maritime climate, and many points in common with England. It is difficult to cultivate wheat and other grains in Newfoundland, and a great degree of humidity with a low temperature prevails there in summer. In autumn, however, the American characteristics are more decided, and the correspondence is greater with the interior. The other localities, and particularly Prince

* Of this winter Daniell (Essays on the Climate of London) notices that Nov. 1821 was 5° above the average temperature with an extraordinary profusion of rain; Dec. 1821, was very warm, early sown wheat growing astonishingly; Jan. 1822, similar; and February still 5° above the average temperature. (Phil. Mag. 1826.) Neither of these months was above the average temperature at Norfolk, New York, or Boston.

Edward's Island and Nova Scotia, exhibit the maritime influence in a softening of the extremes of cold, while they retain a high temperature for the three warmer months. At Albion Mines, Nova Scotia, lat. 45° 34½′, the mean for July and August is 66° each for an average of ten years,* and from the known productiveness of Nova Scotia and Prince Edward's Island it is probable that no considerable part of either would fall below 65° for these months. Still the direct sea exposure, the fogs of spring and summer, the prevalence of grasses and adaptation to pasturage, giving an English air to the climate in contrast to that at the 40th parallel.

The west of France is in part similar to England, and has the same contrasts in comparison with the United States. This includes Holland and the north of Germany also, and the same condition goes southward to the line when the vine may be grown, at Rochelle, lat. 46° 20′. Below this point there is more correspondence in productive capacity with the United States, and the Indian corn becomes a luxuriant and successful growth. Where this succeeds the summer must have a mean temperature of not less than 65°, and it is remarkable that its limiting line at the north is in both cases nearly at the same latitude; it comes in at the west of France at Bourbon, lat. 46° 30′, and it reaches the 46th parallel here at the Bay of Fundy, on the St. John's River in New Brunswick, and on the St. Lawrence River. For this part of the west of Europe there is more correspondence with the United States than for any other portion. It has less rain, but a proportion of sensible humidity not widely different, and similar conditions of cloudiness, frequency of storms, &c. The storms of the west of France are believed to be less severe than those of the United States, and less marked by decisive characteristics, though on this point there is a singular want of practical knowledge. The rains of most of the coast are equally distributed, or the quantity for each month is the same. This is remarkably true at the north of France and over most of the region of maize and vines, but at the south the summer becomes dry and the rains periodic as in Spain and California.

The uplands of Georgia, and the interior northward to Pennsylvania, have some resemblance to France in various points of cultivable capacity, and the averages of temperature, &c., would appear to confirm this more strongly than we find a farther analysis to bear the comparison out. The extremes which occur here cause much of the difference,—it is alternately too dry and too wet, too warm and too cold, to conform to these characteristics of France. The delicate lucerne, and other cultivated grasses which come in below the range of the English grasses in Europe, or in climates warmer than they require, fail here, for this reason, and the finer varieties of grapes, olives, &c., also fail. With a growth adapted to the climate, as Indian corn, tobacco, and cotton are, the success is great and the profusion remarkable, but the difference of climate is so great that the success ascertained for France may never be taken here without trial.

Great persistence in acclimating plants and fruits brought from the west of Europe is required in the whole range of the United States coast, to the south of Florida. A

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* Observations of Henry Poole, Esq. This gentleman has ably analyzed his series of observations to show that the duration of the seasons there is not properly such as can be assigned to the three months usually taken, but that the summer and winter are longer, and the spring and autumn shorter.

In a diagram of the seasons, after the model of those by Howard, the contrast in the fixed and natural divisions of the seasons between the English and American climate is strikingly shown. The natural spring is shown to be but of 66 days, or from the 25th of March to the first of June; the summer of 116 days, or to the 25th of September; the autumn of 63 days, or to the 26th of November; and the winter of 120 days, to March 25th.

colony of Greeks from Smyrna,* in Asia, long since established themselves at New Smyrna, on the east coast of Florida, lat. 29°, a point far south of their native Smyrna, which is in lat. 38° 26′. They planted the orange and various tropical fruits, and appear to have persisted for a time in their efforts to introduce them, but now a few remnants only are left. For much of this country the failure is doubtless due to inadequate effort and attention, but the changes of temperature are sometimes severe. "During February, 1835, a severe northwest wind blew for ten days in succession in Florida, the temperature falling to 7° below zero, (in the latitude of St. Augustine). All kinds of fruit trees were killed to the ground and extensive orange groves were destroyed." (Williams' Florida.) The lowest temperature recorded at Charleston for this month is but 6°, and at Key West 45°; it is probable that the measure given by Williams is too low, though it is well known that oranges and other tropical fruits were almost entirely destroyed in Florida.

Other instances of the destruction of tropical fruit have occurred at frequent intervals here, yet such instances are by no means wanting in Europe and Asia, and they cannot be considered decisive against the possibility of the cultivation of these fruits. Still these and other causes have so far repelled the attempts that have been made, and they undoubtedly present formidable obstacles to the introduction of those of a delicate character, to which an excess of humidity or of rain becomes injurious, and which are quite destroyed by extreme temperatures. The winter of 1835 was the most severe and destructive that has been generally noticed in the history of the Southern States, yet at several other instances, and particularly in 1780, December 1831, January 1852, and the last winter, 1855–6, more or less injury has been inflicted on delicate fruits of tropical origin.

In regard to the sensible climate, or the obvious conditions affecting convenience and comfort any extent of illustrative citation might be made. In all English references, particularly, the Italian climate is lauded for its brilliant skies and freedom from clouds and storms; France is designated "sunny" in contrast with the British Islands, which last are conspicuous for an obscured sky and a sensibly damp and murky atmosphere. These are undoubtedly true as divisions of the west of Europe, and the eastern United States do not positively reproduce either. Italy is better represented in California than elsewhere, and the States north of the Gulf of Mexico possess its clear and serene sky only at intervals, and not as a constant condition. The rains of summer are not suspended here as they are in Spain, the south of France, and Italy; and the air cannot be as clear at that season, therefore. At intervals the serenity of the Italian sky may be established, and the characteristic condition here is this alternation between tropical humidity with its profusion of rains, and the clear and elastic atmosphere which follows a removal of the saturation at any time.

In summer the whole area of the United States is similarly occupied by this predominating feature,—the irregular distribution of profuse showers alternating with entire serenity. No where else are thunder showers such grand and conspicuous phenomena, occurring at intervals on successive days, and with a stately and almost orderly distribution over great belts of the country. In the Northern States they are more constant than in the Southern, or more likely to occur on the afternoon of every day through the warmest month or months, while at the 35th to the 42d parallel they usually occur in belts, continuing even two or three days, and embracing a district

* "Long ago a colony of Greeks who settled at New Smyrna, Florida, had planted the olive, and only sixty years since there were large trees marking the site of that settlement. Recently Mr. Couper, of St. Simons, has tried its cultivation with success." (James Camell, in *South'n Cultivator*, vol. 3, 1845.) The Greek colony was introduced under British rule of the Spanish province of Florida.

equal to that from St. Louis to Philadelphia; this belt or period to be succeeded by one entirely serene, of equal extent and duration. In the warmer years this is the case over the whole lake district, but ordinarily it would be limited to the line named, with the valley of Lake Ontario included.

Near the Gulf of Mexico there is a tendency toward the development of a summer rainy season, and at New Orleans the characteristics of such a season are often strongly marked; the morning of each day being clear, but heavy rains setting in as the heat attains a high point. These always greatly lower the temperature, and cease at evening.

None of these characteristic features which add so much to the beauty and interest of the American summer exist in western Europe in any decided degree. Thunder storms are almost as rare there as on the California coast,* and the rains are more moderate, and equally distributed in time and place. They are particularly rare in Ireland, though there, and in all the west of Europe indeed, they may be very scarce at the remote intervals in which they occur, and then equal to those of the most severe character in the United States. Howard (Climate of London) notices several of these, and gives a list of all which occurred in the series of years for which he gives detailed observations.

In a summary of the Radcliffe observations, at Oxford, England, an enumeration of the entire number of cases of thunder and lightning occurring in twenty-five years previous to 1854 is made, from which it appears that 88 cases of "thunder and lightning" occurred in that period, and 90 cases of "thunder without lightning;" or, rather, this number of *days* is so designated. This gives an average for each year of 7.1 days of both or nearly 3.5 of each alone. Of "lightning without thunder" there is also given a number of 47 in 13 years, or 3.6 days yearly. The distribution of these among the months is given in proportions only, which show, as here, some in every month, and a maximum in July. In the United States it is difficult to find statistics of this phenomenon,—a mean for fifteen years at Mendon, Mass.,† gives an average of *thirteen* days of thunder showers annually; a mean of several points in New York in 1843 *twenty-two* days, &c. The average at nine stations reported in 1839, is *fourteen days*. (Regent's Reports, 1840–44.) But at St. Louis the accurate observations of Dr. Engelmann‡ go much more thoroughly into this observation, and the result shows that a greater frequency exists there than in the Atlantic States. For sixteen years the monthly averages were as follows:

Jan.	Feb.	Mch.	Apl.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Year.
0.7	1.3	2.6	5.7	8.3	10.4	6.9	5.1	3.6	2.4	1 3	0.6	49.

Expressed in *days* the number would be reduced to *forty* perhaps, yet it is readily seen that they are far more frequent here than on the Atlantic coast of New England, and seven or eight times as frequent as in England at the station cited.§ In connec-

* The infrequency of electrical phenomena in connection with rains or showers in California is strikingly shown by Dr. Gibbons' remark in his account of observations for 1855, (Am. Jour. Sci. 1856). "The clouds were sensibly electrified but five times; twice in April, once in August, once in September, and once in December. The lightning and thunder were indistinct except in December, when there was a regular thunder gust with heavy thunder."

† American Almanac, 1849.

‡ Drake's *Interior Valley*, &c.

§ As this is passing through the press an average of five years of accurate observation at Germantown, Ohio (twenty miles from Cincinnati), by L. Groneweg, has been received. He gives the following whole numbers and averages for this period:

Thund. Storms.	Jan.	Feb.	Mch.	Apl.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year.
Whole No.	1	3	11	26	37	50	50	32	24	3	2	3	242
Average.	0	1	2	5	7	10	10	6	5	1	0	1	48

tion with these observations Dr. Drake cites many facts in regard to the frequency and violence of thunder storms in the Mississippi Valley, and notices their rapid diminution in number toward the higher latitudes.

The characteristics of the tornado, or of the hurricane belonging to this class of storms of limited extent, rarely appear in a well defined form in England, and these should undoubtedly be ranked as a distinct class not identified with thunder showers proper. These last are strictly limited storms, in which the barometer rarely falls at all, and though this is also the case in the smaller tornadoes, and it is difficult to fix any boundary between them in the United States, yet tornadoes as a class cause great oscillations of the barometer.

There is no feature of climate more attractive than this constant succession of the showers of summer in the middle and northern latitudes of the United States. They are formed in the belt of westerly winds and move with it; nearly always due east, though the local attending winds usually close from northwest, and for this reason it is sometimes thought that this is their general movement. They are developed by the daily heat apparently,—forming, as that attains its maximum, in cumulous clouds, which begin with the warm hours of the day, and rise in the remnant of a stratum at evening, if not dissipated sooner. The number and duration of these is proportioned to the heat and degree of saturation, and under proper conditions in this respect they may be continued at all hours of the day.

Periods of excessive heat and saturation, of two to five or eight days' duration, are common in the American summer, and quite characteristic of it. The occurrence of these is much more rare in Europe, though they are not unknown. Howard mentions one which occurred in 1808, at which the temperature at London rose to 96° and at Paris to 97°, at both places the heat being prolonged over ten or twelve days. The air in England was clear and dry, and no unusual phenomena were observed apart from the heat.* But one other instance of great heat occurred from 1806 to 1831, which was in July 1825; from the 13th to 19th of this month the thermometer was every day above 90° at the maximum, ranging from 91° to 97°; on the 31st it was at 91°, and on August 1st, 92°. This is the greatest heat recorded in that part of England.

The same author gives an instance of excessive heat in the west of France, at Nantes and Rochelle, which is probably the greatest occurring there during the period of his observation. On July 29th, 1827, the thermometer rose to 105° at Nantes in the shade, and at an elevation of seventy feet above the surface. At Rochelle it rose to 99°.5 on the previous day, and to $110\frac{3}{4}$° on that day,—an unprecedented heat, as it is said, producing disastrous effects on vegetation, &c. In England at the same time it rose only to 89°, though it was nearly as high as this for several days.†

Such extremes of heat are not uncommon in the United States, and they occur at some part of it in every year. The maximum of 100° is frequently found even in Canada, and southward of the latitude of Boston it may be relied upon that temperatures of 95° to 98° will occur once or twice in every summer. These warm periods

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* The observations of Howard at this time are of interest, and may be given here. On July 10th, 1808, the thermometer was at 76° at London, and 82°.6 at Paris; it increased to the 13th, when it was at 96° at London, and 93°.8 at Paris; still increasing at Paris it reached 97°.2 on July 15th, but it had then fallen to 81 at London.

The mean of 13 days at London (Plaistow) was;	for the day,	84°.4	of both, 71°.6.
	for the night,	58.8	
" " at Paris,	for the day,	87.7	of both, 75°.8.
	for the night,	63.9	

† Climate of London, vol. iii. p. 194, 257.

continue over several days also, and if the air is dry the temperature readily rises above 100°. If saturated, or nearly so, it rarely goes above 95°, but the effects are very destructive in these cases, great mortality occurring iu the cities from "sun stroke" as it is called, which is, however, but an exhaustion or depression of the vital powers resulting from the joint action of heat and humidity.

As a representative of those summer heats occurring in the United States the following observations made with great care by the writer at Washington in 1853 may be cited.

	Temp. of air.	Temp. of evap'n.	Pr. ct. of Humidity.
June 30, 9 a. m. . . .	84°	79°	79
12 m. . . .	94	81	55
2 p. m. . . .	98.5	82.5	48
3 p m. . . .	99.5	81	43
4 p. m. . . .	98	79.5	41
5 p m. . . .	86	71.5	47
July 1st, 9 a. m. . . .	85	79.5	78
12 m. . . .	91.5	80	59
2 p m. . . .	95	79	47
3 p. m. . . .	93	78	48

These observations are from instruments properly placed in a small building erected for this purpose in the public gronnds by the Smithsonian Institution. The average of fair exposures would give 103° as the maximum, as was observed at the time. A note published at the time gives these circumstances: "In the sun, and over a non-reflecting surface of fresh vegetation the naked bulb thermometer nearly kept pace with that in the observatory after 10 o'clock of Thursday. Over the ordinary earth surface it rose to 106° iu the sun; in the shade of a tree of moderate size, and open to the general reflection from the surface, it rose to 103°. This last was the correct representative of the average surface atmosphere."

Such conditions are the usual ones for high temperatures in the middle latitudes of the United States. They have generally a low percentage of saturation, often falling to 30 per cent., as was the case at many points iu June 1853, with great variability, however, and frequently an excessive saturation. When this saturation is greatest the air temperature rarely rises to 74°, but it is then far more oppressive than at higher temperatures with less saturation. At New York city in August, 1853, the wet thermometer was at 80° to 84° from the 12th to the 14th, the air at 90° to 94°, and the mortality frightful from this joint effect; over two huudred persons losing their lives in the two days in that city alone.

As the summer advauces the intervals of dry weather usually increase in duration, and in the early part of autumn these severe periods are sometimes of fifteen days' duration. There is no part of the United States north of the Gulf of Mexico aud east of the Mississippi distinguished by the autumn rains which occur in the south of Europe, or by any excess of these over the summer. September is usually more dry at the North and October at the South, than either the summer or winter months. West of the lakes, or of Lake Erie, the rain in autumn rapidly diminishes, and the long, dry, smoky intervals occur in their most complete development. It there continues to grow dry through the winter, which has a very small quantity of water falling in rain or snow. Where the autumn does not differ largely from the quantity of rain at other seasons, as in New England and farther northward, there are still intervals of the serene and beautiful weather so prevalent on the plains. The popular designation of *Indian summer* is universal, and it is held certain that one such period, of some days' duration, will occur in October of every year. Iu Canada this phenomena is in striking contrast with the weather which succeeds it; a few days of singularly mild, soft, and quiescent weather, attended with a dense atmosphere of smoke and dry haze, break up suddenly iu a violent snow storm, perhaps, with severely cold, clear weather.

Kaemtz notices the Dry Fog, or Dry Mist of Germany, which is often carried in to France and Italy by north or northeast winds, and though various suggestions are cited as to its cause, he appears to consider it but the smoke and vapor from the burning peat or marsh grasses in the marshy districts of Germany and Russia. It is here clearly nothing more or less than smoke and vapors suspended in an atmosphere of unusual quiet, and perhaps having an electrical condition unusually favorable to this suspension. The prevalent winds in the United States are from the west, and after the heats of summer immense areas of the dry grass of the plains are constantly burning. This smoke is wafted eastward, and in the light atmosphere it descends, filling the surface air sometimes so much as to give it a stifling closeness.

Several writers have traced a resemblance between this condition and the dry mist of Europe, and they are evidently so far similar as the unlike conditions of surface will permit, and the fact that the winds carry the smoke eastward, except at rare intervals. On the west coast of Europe it is very little known for this reason, and as a constant feature of the later summer and autumn here it strikes most observers as a great contrast between the two countries.*

Kaemtz's description of the obscuration of the sun by this dry mist, and of its deep red tint, and the fact that it may be gazed upon without dazzling the eye, will be recognized as applying to very frequent phenomena in the later summer and autumn north of the 38th parallel in the United States. South of this line this obscuration is much more rare, appearing to cease at the southern border of the belt of westerly winds. Drake remarks that at Cincinnati it is most frequent in October and November, "its duration varying from one to two, three, and even four weeks in different years. A copious fall of rain, sometimes mingled with snow, and followed by hard frosts, sometimes precedes its appearance. The atmosphere during its continuance is tranquil, temperate in heat, and hazy; but not much obscured by clouds. Falls of rain are, however, not uncommon; and in general the whole appearance breaks up with a rain storm, followed by a winter temperature. An apparent smokiness through which the sun and moon, when near the horizon, and especially at evening, appear of a crimson hue, is the great characteristic of the season."

Dr. Drake ascribes it to the burning grass of the plains, and cites the observations of Prof. Loomis at Hudson, Ohio, of Dr. Ray at Cincinnati, and of Dr. Engelmann at St. Louis, to prove that no barometric variation attends the phenomenon, and no important hygrometric or other change. A writer in the Canadian Journal of Science has described it as a peculiarly marked and conspicuous phenomenon at Montreal, with contrasts like these, but more extreme.

There are many instances of this phenomenon in spring, particularly in the western States, but at this season it is much more rare in the States along the Atlantic coast. It is sometimes quite conspicuous in New York at this season, however, and for shorter periods gives the singularly soft, yet close and peculiar atmosphere which belongs to the phenomenon everywhere.

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* In the Report of the Regents of the N. Y. University for 1847, a graphic notice of the "second summer" is quoted from the London Atheneum:—"A writer in the Atheneum after remarking that the periodical return of this in America is about from the 12th to the 17th of November, states that in Switzerland the same phenomenon has been observed from time immemorial, and *l'ete de St. Martin* has passed into a proverb. Now the 11th of November is the fête of this worthy, and from diaries, which I kept during six consecutive years in Switzerland and Southern Bavaria, I find that with the exception of 1837 we had a return of perfect summer weather for four or five days together, and this after the season had apparently completely broken up. In all cases this occurred about that same period, or rather toward the 14th of the month."

In the middle latitudes here the transition months from summer to winter and from winter to summer, are marked by strong and almost constant winds from some point. The prevalent wind is west, and the severest perhaps at a few points north of west, from which it will blow for several days at these seasons in a disagreeable and steady wind. These winds fall to lower latitudes at the Atlantic coast than in the Mississippi valley, though as westerly winds they do not go south of Charleston; on the Gulf appearing as northwest and northeast winds, or true "Northers."

At Washington October to January, and March to May, frequently exhibit these persistent westerly winds, and at points further north they are equally severe and continuous. They are most severe after periods of warm and wet weather, or at the close of general storms, and then they are far more strong and persistent than would be possible except in a belt where westerly winds accorded with the general atmospheric movements.

The chilling northeast winds have been alluded to, and these are distinguishingly American. It does not appear that the same rotation of winds attends great storms in England and on the European continent as here, and when these winds, which here precede every storm or attend it, are experienced there, they attend cold and settled weather only. Such are said to be the northwest winds of England, dry, piercing, and unaccompanied by any disturbance.

On the New England coast the sea influence is always great, and local mists with chilling sea winds prevail very much at certain seasons. The northeast wind is the natural storm wind of all this coast, attending all the general storms as a persistent phenomenon of perhaps two or three days' duration. In all the temperate latitudes the northeast wind appears to be a natural consequence of considerable disturbances of the atmospheric equilibrium, and it is felt on the plains beyond the Mississippi, at the head of Lake Superior, and in Texas not less decidedly, though less frequently and of less duration, than on the coast of New England. But in the last locality it bears the ocean scud and mist with it, and produces an extremely chilling effect at all seasons. In winter it is often warmer than objects on the land, and it loads these with a brilliant coating of ice, producing one of the most striking and beautiful of appearances. This peculiarity is at its maximum in Newfoundland, where the proximity of the Gulf Stream produces favorable conditions for this ice formation whenever the wind is from the sea in winter. These instances are rare west of Lake Erie, if not wholly unknown.

There are many evidences that the peculiar chill of a northeast wind preceding or attending a storm in the eastern States is not dependent on contact with the sea, as there appears to be no essential difference between its peculiarities when first beginning, and when it is about to cease after three days' duration. For a considerable time at first it does not come from the sea at all, and when beginning at Washington or Philadelphia, opposite winds may be blowing at New York and Boston. It is clearly true of most of these storms that they move northeastward, and contrary to the direction of the surface wind; that being, in fact, but the incident of other and greater phenomena. Its chilliness and high degree of saturation are nearly the same in all cases, though the great quantity of vesicular vapor which it contains, and deposits in ice on bodies below the freezing point, undoubtedly is more directly derived from the sea.

As a rule the winds bearing a profusion of vesicular vapor in low clouds and mist are here from the east and northeast, and in England and France from the west and southwest. We have at times the dry, absorbent northeast wind of England, but it is rare, and if persistent soon changes its character.

Neither of these corresponds with the *Mistral* of the Mediterranean coasts and in the south of France, or the *Bora* of the Gulf of Venice and the Adriatic, or the *Etesian*

winds of Greece and the eastern Mediterranean. These have their representatives in the Northers of the Gulf of Mexico, and they will be to some extent described and compared in a subsequent chapter. Each is a north or northeast wind of a severe and chilling temperature, often accompanied, in the first two named, by dense mists.

Schouw gives, as the rule for the west of Europe, prevalent southerly winds in winter, and particularly in January; frequent east winds in spring, in March and April, with less of west winds at this season; predominating west winds in summer, which reach their maximum in July, and are associated with frequent north winds. In autumn the southwest and south winds again acquire ascendancy. The cause of the predominance of southwest winds in the west of Europe lies in the distribution of heat, simply; the isothermals extend from southwest to northeast on approaching that coast, and the direction of these lines is followed instead of that of the parallels.

The greater severity of the wind here in the colder months renders the actual differences of temperature more decided to the senses than is apparent in instrumental observation. The piercing and violent northwest winds which follow a storm or a period of warm weather, appear colder, or are felt to the senses as colder, than the thermometer would indicate; and the intense cold of winter in the interior is not so uncomfortable as it is at Boston, though the thermometer may fall many degrees lower. The Atlantic coast is one of almost constant atmospheric disturbance, or the conditions vibrate in one direction to return immediately through the same range. There are none of the "dead calms" which exist in the interior of continents in winter as well as in summer, and in mid-ocean apparently in the same manner. Whether the Gulf Stream alone is the cause of these changes, or whether the mere contrast afforded by the position of the sea, unequally heated as it is, to the land which differs in temperature so largely for the latitude, is not clear; but to some cause an almost constant movement is due.

In winter the sensible climate of the United States differs as largely from that of the west of Europe as at any other time. Here the abundance of snow requires the use of sleighs regularly as a means of conveyance at least as far south as New York City, and at intervals, as in the winter of 1852 and 1856, snow lies for several days and even weeks as far south as Washington. In the last winter sufficient snow to form a sleigh track lay in the streets from Dec. 29th to February 10th, and much snow remained in the vicinity four or five weeks later. In England the use of snow on the ground as a means of facilitating conveyance is very rare, and it is only at remote intervals that a sufficient quantity falls for this purpose. It can scarcely be regarded as a constant phenomenon in any part of the west of Europe, as understood in this comparison, and it becomes such only in Norway away from the coast, and in Sweden and Russia. Between the lines of latitude which bound it as such, or as a permanent covering of the soil for a part of the winter regularly, however short, there is a contrast on the opposite coast of the Atlantic of at least fifteen degrees in the meridian of St. Petersburg, and over twenty degrees—nearly twenty-five indeed—in the meridian of London.

From the Atlantic coast westward a line nearly at the 41st parallel would give the limit of what might be called the regular existence of snow as a covering for the ground in winter, though at the west end of Lake Erie the line would go north nearly a degree and a half. For some reason the winter at the western extremity of Lake Erie and at the southern point of Lake Michigan is warmer, and has much less snow for its latitude than Connecticut. The number of days on which snow falls in the year diminishes from an average of 25 at Pittsburg, to one of 10 at Cincinnati, and of 15 at Washington. At Cincinnati for sixteen years, 1839 to 1855, the careful observations of Dr. Ray give a mean of nineteen inches of snow for each winter, the greatest in one winter being fifty inches, but the number of days on which it fell is not given.

It is the most decisive proof, perhaps, of the extreme character of the American climate in comparison with the European, that the snows of winter are thrown so far south and into latitudes where the summer heats are tropical.* It is probably due to continental position mainly, as the fall of snow noticed at Canton, which has been cited in another connection, would go far to show. We have seen that snows are frequent and sometimes persistent for weeks at Washington and Cincinnati at the 39th parallel. This differs little from the latitude of Lisbon, Messina, and Smyrna; at each of which snow is unknown. The winter of Milan, according to the citations of Howard, would not differ greatly from that of Washington in regard to frequency and quantity of snow, its position being at 45° 30′ north latitude, or six and a half degrees north of Washington. Paris and London do not differ largely from Washington in regard to snows, though each is milder and more equable.

Like all the prominent points of variability in the climate of the west of Europe, these extremes of cold occur at remote intervals, and do not make up a constant element of the climate, as in the United States. In the average the soft winter of the British Islands strikes us as an extreme contrast with the Atlantic coast here, the tropical and half-tropical fruits bearing the open air in the southwest as at Penzance, the whole country being usually green with grass through most of the winter, and mists, humidity, and moderate rains taking the place of the sharp frosts and snows which prevail here as far south as Philadelphia.

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* The frequent occurrence of snows in April and even in May in the latitude of Washington is a striking phenomenon of the climate. As early as 1755 Richard Brooke, "of Maryland," communicated observations to the Royal Phil. Society in which he remarks of April, 1755, "on the 16th it snowed as hard as ever I knew it to do;" and of the same month in 1757 "the wettest and coldest April within man's memory." (*Phil. Trans.*, 1759.) At several instances in recent years a quantity of snow has fallen in April in several instances a foot or more in depth in the interior valleys of Virginia. On April 22d, 1856, a small quantity fell at Washington, and near a foot in depth in Upper Virginia.

A remarkable instance of the extension of snows southward at extreme intervals is given by Abiel Holmes, of Charleston, S. C., in a paper communicating the results of many years of observation at Charleston to the American Academy. On January 10th, 1800, there fell at Savannah the deepest snow accompanied by the greatest cold ever remembered in Lower Georgia. The snow was three feet deep on a level." The yearly extremes of temperature for several years are also given by Mr. Holmes, as observed at Charleston.—*Memoirs Am. Acad.*, 1809.

	Max.	Min.		Max.	Min.		Max.	Min.
1750	96°	25°	1756	96°	26°	1793	89°	30°
1751	94	23	1757	90	25	1794	91	34
1752	101	18	1758	94	25	1795	92	29
1753	91	28	1759	93	27	1796	89	17
1754	93	22	1791	90	28	1797	85	22
1755	90	27	1792	96	20	1798	88	31

On March 6th, 1843, snow fell for fifteen hours at Augusta, Georgia, covering the ground fifteen inches deep. (Holbrook in *Am. Alm.*, 1845.) In this month snow fell over a large area of the States bordering the Gulf, embracing New Orleans and Mobile.

Ramsay says (Views of South Carolina, vol. 11, p. 52): "On December 31st, 1790, wind northeast, a severe snow storm began in Charleston which continued twelve hours. In consequence the streets were covered with snow two to four inches deep. Another took place on February 28th, 1790, wind northwest, which continued several hours and covered the ground five or six inches deep. Similar snow storms fell in January 1800, and were then thrice repeated in twenty-three days, amounting in all to more than ten inches.

VIII. COMPARISON OF THE BASIN OF THE GULF OF MEXICO WITH THAT OF THE MEDITERRANEAN SEA.

THERE is a degree of similarity of position between the Mediterranean and the Gulf of Mexico which affords an opportunity of illustrating the peculiar climate of each by some detail of citation and comparison, though much of this peculiarity is in the contrasts they present, or in their distinctiveness and differences. In variety and interest the Mediterranean basin exceeds the corresponding basin, as it is in some respects, of this continent, and its climatology could be successfully and thoroughly treated only at a greater length than can possibly be undertaken here. Spain, Italy, Greece, Palestine, Egypt and Algiers, each deserves a treatise of more space than can be given the whole in this place, and in the applied relations of cultivation, and of sanitary adaptation, they are of almost inexhaustible interest. With less variety in the climates of the Gulf of Mexico, there is still the greatest practical importance attaching to them as the transition district from temperate to tropical characteristics for this continent, and it would be more definite, perhaps, to designate the comparison as one of the transition climates of the two continents,—one embracing the Mediterranean basin in a wide belt, with Persia, most of India, and China; and the other the narrow line between the tropical islands of the Gulf, and a line sufficiently inland to reduce the tropical preponderance.

Schouw has written an elaborate work on the climate of Italy which is among the most complete of European climatological works, and which fully illustrates the minuteness of division required in treating the various belts and local districts. Not only in the quantity of rain and measure of temperature, but in all the associated results of a practical character, which are generally widely separated in distance, Italy and all the bordering States of the Mediterranean exhibit belts of extreme contrast, and each of these contrasted localities has a very limited area. The diversity is so great in the Alpine border of Italy that the entire range from tropical to arctic growths is comprised between San Remo and the vicinity of Nice, where palms thirty or forty feet high abound, to the upper valley of the Alps, where vegetation

ceases. The existence of areas of water surface, and of extended coasts in both the special districts here compared, necessarily supposes some agreement of climatological phenomena.

The difference of latitude between the north coasts of the Gulf of Mexico and the Mediterranean is large, and the respective positions are much more variable than the climate. From the Lower Rio Grande in Texas to Mobile, the difference is five degrees of latitude, 25° to 30°; while the extreme points at the north of the Mediterranean range from 35° and 36° north latitude at Candia and Gibraltar, to 46° at Trieste and the Gulf of Venice. The Mediterranean climates are far less variable than this difference would imply, however. Cadiz and Genoa differ in position eight degrees of latitude, yet their mean annual temperature differs less than one degree. Similar instances of equality in temperature exist along the very variable line of the north coast of that sea through its whole extent, and with the exception of the Gulf of Venice, this entire coast is nearly equally adapted to the tropical admixtures which mark the transition climates here only at the borders of the Gulf of Mexico, between 25° and 30° north latitude. The west of Europe is not only warmer at this line of transition, but warmer in a singularly irregular and unequal division in regard to the area so defined. From Cadiz to Genoa there is, as said before, less than a degree of the thermometric change for 8° of latitude, the annual means being 62° and 61°.1 respectively; returning 3½° of latitude south to Naples the mean is 60°.3, or even below that at Genoa. At Palermo, Sicily, 6½° south of Genoa, the mean is but 63°.1; at Venice, 7½° north again, and beyond the influence of the greater area of the Mediterranean, the temperature is 55°.4, or a change of only about one degree of the thermometer for one of latitude. Here 8½° of latitude from Pensacola to Annapolis reduce the mean temperature from 68°.7 to 55°.4, or 1°.56 of the thermometer to one degree of latitude. The Gulf of Venice is too decidedly exceptional to illustrate the general comparison, but it shows that the characteristics of the transition zone are many of them carried, in the Adriatic, to the latitude of Montreal.

The basin of the Mediterranean is particularly deficient in rain and in atmospheric humidity, in comparison with the Gulf of Mexico. It not only lies on what we find to be the dry side of the continent in this latitude, but it is surrounded by a land surface of intense aridity, into the atmosphere of which the clouds and light rains are often driven to be almost instantly dissipated in its furnace-like heats. The evaporation from the sea itself gives some rainy localities, as on the bordering Alps, and on some of the mountains of Asia Minor and the Caucasus. But all this amounts to little in comparison with the exces-

sive saturation and profuse rains of the borders of the Gulf of Mexico here, which give a summer and a winter rainy season almost equally profuse along the north coast, against a light autumnal rainy season on the Mediterranean. In short the correspondence is on corresponding sides of the continents only, and if the Gulf of Mexico were similar in position to the Gulf of California, yet extended inland like the Mediterranean, the districts of the various local peculiarities now bordering the Mediterranean would be reproduced. And to find the equivalent of the Gulf Coast in regard to the more precise features, the comparison must be sought in India and China, where the correspondence of continental positions exists.

Notwithstanding these general facts the two areas not only illustrate each other in every respect when compared, but they furnish many practical points of agreement. They both form portions of the transition belt between tropical and temperate climates, and in this belt the greater efforts of cultivation are constantly made to extend production, and to multiply resources by introducing growths from each extreme. Tropical fruits, sugar cane, rice, and many other staples have been brought from the tropical side, and the hardy grains and grasses from the temperate side. The interchange of population is greatest here also, and all the sanitary relations of climate are here exemplified and illustrated.

The Mediterranean illustrates all the forms of precipitation in storms on a scale more or less extensive, though usually in more limited and local areas than here. In the Black Sea and the Gulf of Venice the correspondence is with the lake storms of the United States;—in the Black Sea it is so very closely, if the very meagre information we have in regard to them is correct, supported as it is by the analogies of position in latitude, and to some extent in regard to continental position. Over the Adriatic and other northern portions of the Mediterranean there is a greater or less degree of development of the general rains of the colder months, if not to as great an extent as in the Black Sea. From these wide spread rains the entire range of showers, thunder-storms, and those of the class of thunder-storms which have so much violence as to be called tornadoes, typhoons of the smaller class, water-spouts, and storms but a few degrees below the West India hurricanes in violence;—all occur in some part of the wide belt occupied by this interior sea. Many of them are signally local and peculiar in consequence of local peculiarities of position, and the highest form of hurricane is rarely attained anywhere. The hurricanes of the Gulf of Mexico are equalled only in the Indian Ocean in truth, where the open access to tropical seas is similar, and the area is sufficient for their full development.

But the storms of the Gulf of Mexico less than the hurricane have the amplest representation in the Mediterranean, particularly along the entire extent of its varied and irregular coast. In the Adriatic or Gulf of Venice, particularly, the severest storms are much like those now well known under the name of *Northers* in Texas,—heavy, sudden, northerly blasts called *Boras*, and like those of Texas they occur through the colder months, and most severely in autumn. Smyth describes them as peculiarly sudden and violent;

"—rushing down from the whole line of the Julian Alps with such irresistible fury that not only numbers of vessels are sacrificed, but they ravage the shore also, being dreaded as much for the suddenness of their attacks as for their violence."

The resemblance is striking when compared with the Norther of Texas by the aid of Admiral Smyth's description, who cites the appearances when the *bora* is coming on.

"It may be known some hours beforehand by a dense, dark cloud on the horizon, with light fleecy clouds above it, a lurid sky, and a breathless, speaking stillness. Its general source is between north and northeast, and its most usual continuance about fifteen or twenty hours, with heavy squalls and terrible thunder, lightning, and rain, at intervals."

These storms are usually accompanied with a fall of the barometer, and Admiral Smyth regards this indication as always a sufficient warning. One occurring in July, 1819, occasioned a fall of the mercury from 30.15 inches to 29.77. These are evidently more like the *northers* of the western part of the Gulf of Mexico, than the hurricanes of the West Indies and the Gulf Stream, and in the Adriatic they are more abrupt and sudden than they would otherwise be, because of the proximity of the eastern Alps.

The western part of the Mediterranean, from Corsica to Gibraltar, is characterized by similar furious north winds in winter, especially in the vicinity of the Pyrenees; and in the Gulf of Lyons from the Alps. These are less regular than in the Adriatic, but they are apparently similar in being produced by the sudden rarefaction of the basin of the sea, and the supply of atmospheric masses rushing from the adjacent mountains. One of these winds is designated the *mistral;*

—"the *mistral*,—the *bize*, *la grippe*, and one of *les fleaux de la Provence*;"*—"it is injurious to fruits and vegetables, and all trees exposed to it become bent."

This is directly derived from the snows and ice of the higher Alps, and it is a marked feature of the climate of the valley of the Rhone. As there are no mountains near the coast of the Mexican Gulf these

* Admiral Smyth quotes a couplet, in addition, significant of the popular appreciation of this *mistral:*

La Cour de Parlement, le Mistral, et la Durance,
Sont les trois fleaux de la Provence.

peculiarities could not be anticipated in the same degree; they are consequently less marked, and the storms producing violent northerly winds are of longer duration. In New Mexico and lower California there are some points of identity with these to be found in the sudden storms of spring and autumn, though a heated sea basin, as in the Gulf of Mexico and the Mediterranean, is necessary to produce the fullest degree of these sudden rarefactions and contrasts of density, and the consequent bursts of wind.

The *Northers* of Texas and the western part of the Gulf of Mexico are preceded by the same heat, humidity and "speaking stillness" near the time the wind changes, which are so graphically described by Smyth as belonging to the *Boras* of the Adriatic, and, indeed, to the more considerable northerly storms of the vicinity of Sardinia and the Gulf of Lyons. In a paper read by the author before the American Association for the Advancement of Science in 1853 some extracts were given from the manuscripts of Berlandier, late a resident of Matamoras, near the mouth of the Rio Grande, which are among the best existing descriptions of the peculiar attendants of these storms. The sound of the breakers of the coast he reports as there being distinctly heard ten to fifteen leagues in the interior.

"Inhabitants of the coast have observed that when the wind is about to change *the sound of breakers changes its direction*, and is heard in the direction from which the wind is about to come. After having been heard for a time of greater or less duration, the sound diminishes gradually, and at length ceases entirely as the new wind appears on the surface of the earth. This phenomenon is remarked particularly in winter, when the wind first blowing is from the south, and the wind from the north is about to come on."*

Berlandier notes a point which appears to have escaped Admiral Smyth, namely, the inquiry whether these storms come from the north or from another direction, and makes the following remark of this case:—

"These phenomena throw great light on the point of origin of winds, and confirm the observations of Franklin, who was the first to remark that violent north winds commenced to blow at the south, and that it is not until after many hours that they arrive at the most northern points reached by the storm."

"The first of May, 1847, an Italian sailor was stationed on the coast of the Gulf in correspondence with me at the rancho of Mezquital, and we fully verified the pheno-

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* The following is the remark with which these notes were introduced in the paper referred to: "Dr. Berlandier, a French physician of great ability and accuracy of observation, made meteorological observations for many years in northern Mexico, at San Luis Potosi and other interior towns, but mainly at Matamoras. Furnished originally with instruments by a society of physicians at Geneva, and reporting his observations then, he afterwards continued a long series for his private purposes. His death occurred a year or two since, and the manuscripts were purchased recently by Lieut. Couch of the U. S. Army, and are fortunately preserved, though still in manuscript."

menon. Watching the sound of the breakers it came at length to be distinctly in the north, but that which fixed our attention still more was an extraordinary heat of the waters of the Laguna Madre, and the presence of a series of cumulous clouds at an elevation of 60 degrees above the northern horizon. This appearance remained through the morning. Finally, an hour after midnight, the wind commenced from north-northeast, passing to north-northwest in the higher regions, and as the wind began to blow the noise of breakers ceased."

"We assured ourselves by positive observations of the extraordinary variation of temperature, and the most unseasonable heat of waters and trees, and I do not believe it to be produced by the intense heat of the previous days ; to what other causes it may be due I cannot tell. It may serve the purpose of other meteorological observers attending to this phenomenon to know that it is not only remarked of the lakes near the coasts, but that from the reports of people of the country I am assured that the waters not far from the coasts, (fifteen or twenty leagues) exhibit similar changes of temperature when a change of weather is about to occur. The low barometer was very notable on the first of May, the day referred to, and the heat excessive."

Of the sudden approach of these storms Berlandier remarks the appearance of a conspicuous instance :—

"On the 31st of December, 1843, the south wind had blown all day and continued moderately through the evening. I had prepared to take the altitude of several stars when I was struck with the appearance of the horizon in the north-northeast—a species of circular band appearing there with its convexity toward south-southeast. Thinking it, at the first moment an aurora borealis I observed its phases with attention, and soon saw it to be an immense cloud. A remote sound of a storm was heard, the wind at south changed to west when the front of the cloud attained an elevation of fifteen degrees, and then the north-northwest wind began, continuing through the night. In less than one minute this frightful cloud had covered half the sky, in strong contrast with the perfect serenity of the other portion in which the moon was shining brilliantly. The perfectly homogeneous character of the cloud was the most conspicuous feature of grandeur. Arrived at the zenith it appeared to envelop the earth, covering just half a sphere. The color was a yellowish-white, like that of the moon in the telescope, it appeared luminous, and the anterior and posterior borders as if cut after a model."

There are clearly many points of similarity in the storms of these two bodies of water, the Gulf of Mexico and the Mediterranean, as they both present comparatively highly heated and humid local atmospheres in juxtaposition with mountains or cool and elevated plains. Both are marked by changes of a similarly abrupt and extreme character, and, indeed, it scarcely seems necessary that mountains should be present to cause these extreme changes since they occur in the Gulf of Mexico at a distance from the coast, and in considerable numbers along its whole extent to Florida. The first condition of a warm and humid local atmosphere is always necessary, and from the storms of the United States coast it may be inferred that the presence of mountains, as of the Alps at several points near the Mediterranean, only intensifies the phenomenon without essentially changing its character. The particular point of progression, if these storms have progressive movement, also deserves attention, and the evidences are most conclu-

sive here that the north wind does not go down from the north southward, but that it recedes as the attendant of a body moving generally from an opposite, or nearly opposite point. Probably there is little movement in most cases, however, and the characteristic action is mainly confined to the basin-like area of the sea, and to the coast in its vicinity.

Some of the greater storms of the Gulf of Mexico appear to be continued along the Gulf Stream in the Atlantic Ocean, and they either are identified with the storms of an extended path, coming up from tropical seas and recurving in temperate latitudes, which have been so thoroughly examined by Redfield, Reid and others, or they begin as storms of a different class, and become merged in these by accidental connection with some one of them at its passage or formation. The West India hurricane is one of the most violent storms known, and only paralleled in the Indian Ocean, but many of these are too far from the United States coasts to come into the present purpose of comparison, and the class has, also, no corresponding class in the Mediterranean. But the more local whirlwind storms and smaller typhoons, as they are designated by Admiral Smyth, are quite frequent in the Mediterranean, and they correspond more nearly to the storms of this whirlwind character in the northern and western parts of the Gulf of Mexico. When these occur in the colder months they become greatly extended, and they then sometimes appear to go eastward regularly, and to follow the Gulf Stream when they reach the Atlantic Ocean. Admiral Smyth distinguishes those of the central latitudes of the Mediterranean as apparently derived from the gyrations of the water-spout, and as being often particularly violent in this local whirling.

"The noted Prester of the Greeks, the destroyer of those at sea; of which Lucretius (*lib.* vi. v. 422 &c.) gives so terrific a description. But though most sailors still believe it to be dreadfully dangerous, and small craft have been known to founder immediately on being struck, in most cases it would probably be productive of no serious injury to a vessel of tolerable size."

The "typhoons" thus described by Smyth are whirlwinds of the most limited character only, similar to those of the land.

"The most obvious instances that have passed under my notice are the vorticular columns of sand in the deserts of Northern Africa. From such currents of air rushing through the atmosphere and along the surface of the sea with an impetuous spiral rotation, there very frequently result, in the warm months, those extraordinary phenomena somewhat inappropriately named water-spouts."

These are equally abundant in the Gulf of Mexico, but the first allusions are rather to the violent local storms with which these water-spouts are generally associated. These are different from the northers,

and also different from the greater rotary storms and the West India hurricanes. Like the thunder showers of summer they are rarely attended by any fall of the barometer, and this is particularly remarked by Admiral Smyth of his many years of careful observance of them in the Mediterranean. The *bora* of the north coasts of the Mediterranean, as well as the *norther* of the Gulf coast, is attended or preceded by a considerable fall of barometer, and the West India hurricane causes the greatest known depressions, except, perhaps, those of the Indian Ocean.

The Black Sea is, as has been said, more like the great lakes of the United States than the Gulf of Mexico, and Smyth briefly describes its storms as hard gales of short duration, mainly from the west. Neither of the classes of storms just alluded to appears to be known there.

Rare instances of severe storms of two or three days' duration occur in Texas, which sweep over the whole of the United States coast of the Gulf, and which are intermediate between hurricanes, northers, and wide general rains. One of these occurred in September 1854, which was extremely severe in the vicinity of the lower Brazos River, alternately blowing from all points. Its duration was three days, and it extended as far as Pensacola, Florida, but no farther eastward. It was also unknown in the upper part of Texas, appearing to have been central at the point named, and to have extended as a heavy rain along the Gulf coast some distance eastward, but with less violent winds. Near New Orleans a large quantity of water fell, at Baton Rouge 5½ inches in five days of its continuance.

It does not appear that the Mediterranean storms participate in any general movement. They are even more conspicuously local than those of the Gulf of Mexico, and always without evidence of the general movement which belongs to the winter storms of the United States, and, probably, equally to those of central Europe. This fact not only proves the position of that sea to be in the transition belt, and where no general atmospheric movement exists, but by necessary implication confirms the hypothesis of movement assigned to the higher latitudes. Thus the storms of the great lakes in the United States are never stationary, but invariably move eastward at a regular rate, when, if no difference in atmospheric movement existed, there could be no solution of this movement; while those of the Gulf coast in summer, and those of the Mediterranean coast in Europe, have no general movement.*

* In the whole of Admiral Smyth's interesting description of the storms characterizing different parts of the Mediterranean, the *localization* of all, under a great variety

The whole class of details respecting the storms and weather of the various parts of the Mediterranean as given by Admiral Smyth is exceedingly interesting, not only for graphic fulness and truthfulness to historic description, but as affording the solution of some of the complicated problems of storms and of atmospheric dynamics generally. The meeting of contrary winds, the passage of strata having a considerable movement from opposite points beneath a flag at 130 feet elevation, with many other similar incidents, show how easily the violence we experience in storms may be induced by condensation of

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of historical and popular names, derived from local peculiarities mainly, stands out prominently in the representation. The *Prester* of the Greeks, now known as the typhoon, and common to the eastern areas of the Mediterranean; the *Bora* of the Gulf of Venice, with the diminutive *borinas* for those of the lightest character; the *Solano* at Cadiz, which is at southeast, like the southeast phase of a norther or Gulf storm; the *Mistral* of the French coasts, a chilling wind not necessarily attending a storm; the *labeschades* and *ouragans* of Tuscany—*gusts* as they would be termed here; the famed *Sirocco*, which is but a southeast wind characterized by the burning heat of the deserts, and afterwards loaded with humidity in its passage of the sea toward Sicily. At first it is attracted toward a humid and rarified locality, and is damp and sultry, but as it continues its original heat and aridity control, and it is intensely dry, "while from seeming dryness it rives unseasoned wood and snaps harp strings, it also makes metals oxydize rapidly, mildews clothes, and makes everything clammy." (Smyth.) The list of local terms may be greatly extended; the *Gregale* at Malta, "a dreaded northeast wind which rakes the harbors of Valetta;" the *Maestrale*, a violent northwest wind of Sardinia, bending trees, &c.; the *Siffanto*, a southwest gale, and the *Furiani*, a southeast gale, of the Gulf of Venice; the *Raffiche*, or sudden squalls from the mountains at Sardinia and in the Gulf of Corinth; the *Etesian* winds (annual breezes) which form an easterly or northeasterly wind of monsoon character in the Archipelago and vicinity; the *Euroclydon* of Paul's shipwreck, which, as a winter wind and storm of the Adriatic it is difficult to identify with any subsequently defined, though undoubtedly well known then; with many others known by names of less frequent use, are all simply localized winds or storms, belonging to certain narrow bays or portions of the sea. Generically they are all the same, and but the different forms the agitation caused by the presence of the elements of a fall of rain—high temperature and great saturation—puts on in restoration of a disturbed equilibrium. In the larger areas of the Eastern Mediterranean only the whirlwind or typhoon form appears, which shows that this gyration requires open water surface to be developed, ordinarily, and that these local gulf areas rarely give sufficient room for it to be formed.

Of the violence of these local winds the author just referred to gives some striking proofs in the citation of places kept bare of vegetation by them. "In winter the flaws and gusts of wind are often furious; and this impetuosity is severely felt in the vicinity of the Pyrenees, at the eastern bases of which I have observed some very remarkable weather-worn rocky steeps." The Solano or Levanter of the Gibraltar pilots, although it comes over the land, is so violent as to justify the Portuguese proverb which makes the gravel "fly before it;—*Quando con Levante chiove, las pedras muove.*" Of the *Bora* in the Gulf of Venice he says, "there are also districts rendered nearly uninhabitable by it. As the maritime cliffs and surfaces of those shores which are most exposed to the bora are well marked—for not a bush nor a blade of grass can grow on them—the local craft usually anchor opposite the points where vegetation is most abundant."

moisture in a small area, and how truly the presence of moisture and its condensation originate all these phenomena.

The calm belt of the Mediterranean, or that which has no regular movement with either the westerly or the trade winds, is a very wide one, affording much more space for these local phenomena than we have here. In summer these local storms in the United States appear to come up as far as the 35th parallel, below which local and violent rains embrace the entire precipitation north of the line where it is tropical in its profusion. This line traverses the peninsula of Florida nearly at the latitude of Fort Brooke, Tampa Bay; or perhaps at the 29th parallel, and in some seasons it includes a portion of the delta of the Mississippi. The lower portion of the Rio Grande Valley is irregularly included also. With these limits the quiescent belt has a width of but five degrees of latitude in summer, and in winter it includes the lower part of the peninsula and Lower Texas, apparently receding from the land entirely at Mobile and New Orleans. In Europe it goes to the 45th parallel in summer, west of the Black Sea at least; and reaching southward to the geographical line of the tropics, probably, or covering about twenty degrees of latitude. In winter its average would be five degrees less, but in both cases the width of the transition belt for the two continents, is widely different, and the space where we may look for phenomena correspondent to those of the Mediterranean is here relatively very small.

None of the historic interest which assists so much to define and identify them, has as yet attached to the prominent meteorological phenomena of the Gulf coast. There are also few or no highlands or mountains adjacent to the Gulf of Mexico, which could originate the winds and squalls of peculiar violence prevailing all along the northern shores of the Mediterranean. In the tropical latitudes there are, it is true, mountains near the Gulf in many localities, but proximity to tropical mountains certainly does not develop such phenomena. All the northern shore of the Gulf is singularly level and low, and only in Texas are these highlands within possible reach of its influence. In this part of Texas the more violent northers occur, though there seems, from what has before been said in regard to the area influenced by these storms, to be little in the north winds which may possibly be attributed to them *as coming down from highlands*, and they certainly never come from the Rocky Mountains. It is highly probable that much of the violent rush of air in the *boras* and other storms of the north coast of the Mediterranean is a vertical displacement, and not a horizontal rush from the mountains of the vicinity, though the presence of mountains would develop and localize the phenomenon. So if the north shore of the Gulf of Mexico were skirted by hills and

mountains, bays and eddies would be found where the saturation and high temperature would culminate more frequently, and develop an infinite number of local and single agitations or storms, rendered singular or peculiar by peculiarities of position.

Admiral Smyth infers that the gigantic ranges of mountains encircling the Mediterranean constitute such a basin as would naturally and certainly obstruct the aerial currents of other parts of that continent; the Atlas Mountains at the south and southwest being practically continued in the ranges of Spain, to join the Pyrenees and the vast masses of the Alps; and these last being little interrupted in their easterly continuation till they constitute a wall in Syria on the east of the whole sea.

"Such is the fickleness (of the Mediterranean winds) as concerns direction, force, change, and temperature, that a complete cognizance of the laws which regulate their course might be despaired of but for the conviction that there is nothing fortuitous in physics."

Yet if the view taken in this work in regard to systems of atmospheric circulation be correct, the general quietude of the atmosphere of the Mediterranean Sea is not surprising, since there is no general movement in progress, in which these minor changes might play a general part, and in which they would, in the nature of symmetrical changes and movements, become agitations of a large area instead of a small one. Indeed the extremely local and subordinate character of winds is often illustrated by Smyth, as in the following case:—

"A strong levanter, in December, 1796, fell heavily on the British fleet at Gibraltar, not only rendering them powerless spectators of Villeneuve's squadron running through the strait to the westward in safety, but it was also nearly fatal to the *Gibraltar* and *Culloden*, while the *Courageaux* was driven on the Barbary shore and dashed to pieces." . . . . "I was once off Milo, standing for Attica with a leading southerly breeze and fine weather, when unexpectedly the wind shifted smack to the northward in a heavy squall by which the sea was thrown into an up-and-down agitation, the crests of the old waves being cast over us in a foaming spray. As this subsided, the wind with us still at the north, a vessel was seen in the east descending the Archipelago before a brisk easterly breeze."

The space covered by the Mediterranean is surely sufficient to give free movement to any atmospheric circulation belonging to the latitudes, notwithstanding its mountain boundaries. It is, in truth, a belt of calms, disturbed only by the agitations peculiar to it, or originating nearly in its own area. The severer hurricanes of the Gulf of Mexico are not known for the reason that sea room sufficient to originate them does not exist; neither in evaporating surface nor in an unobstructed field over which they may move until completely gathered.

The greater severity of the disturbances induced by precipitation in the Gulf of Mexico in comparison with the Mediterranean is fully

accounted for by the greater humidity of the atmosphere here. In another place evidences of the extreme dryness of the air at various points on the north shores of the Mediterranean have been cited from Smyth and others—dew is rarely deposited in Attica, and on many parts of the coast in Syria, and, indeed, over the whole basin at the warm season. The percentages of saturation cannot be given in comparable measures for the two districts, but it is well known that the air of the Gulf of Mexico is extremely humid. Heavy dews are deposited on the peninsula of Florida, particularly in summer; tropical floods of rain fall; instruments are kept bright with great difficulty; mildew occurs abundantly; plants endure long absence of rain without injury, &c. At Fort Meade, latitude 28°, the weather is reported by the medical officers to be extremely oppressive just previous to the rainy season, which begins in May. Rain then falls almost daily until September, and sometimes so profusely as to flood the country and render it impassable from the quantity of surface water. Such is particularly the case during the present summer, 1856, when all the country southward of Tampa Bay has been rendered impassable from excessive rains through June and July. For the period from April to October the climate is very enervating from warmth and moisture over most parts of the peninsula of Florida, and in the plains bordering the Gulf on all sides, where local relief from sandy pine plains is not afforded. In the west of Texas, however, the humid belt is narrow, and often the arid atmosphere of the inland districts displaces the Gulf air for a time.

In Florida the land breeze and sea breeze alternate in their natural order, constituting all the atmospheric circulation for the warmer months. The sea breeze is the coolest and least oppressive, and for some portion of the time decidedly bracing; with a temperature five degrees or more below the land wind. Such is the case all along the coast indeed, and the islands and beaches of the most complete exposure are made summer stations for troops, and pleasure resorts from the cities. Various points and beaches near Pascagoula, Mississippi, have been made summer military camps for troops stationed at New Orleans and Baton Rouge since the first occupation of the country, and they afford retreats from the malarious local atmospheres of the rich alluvial lands, and a reduced temperature with a more elastic air. The back ground on this part of the coast of Mississippi is an extensive pine forest, and this adds to the sanitary advantages of the position. *Isle Derniere*, or Last Island, nearly south-southwest of New Orleans, is also a favorite pleasure resort.

In describing the general storms of the United States the hurricanes of the Gulf of Mexico are noticed to some extent, since such of them

as follow the Gulf Stream into temperate latitudes belong more particularly to that classification. The whole area is a *hurricane district* and it has its "hurricane season," though the north coast, with which we have here to deal, is not so extreme in regard to them as the tropical latitudes. The level shores of Texas, Louisiana, and the States eastward to South Carolina, belong to this hurricane district, and though the statistics of their occurrence are very difficult to collect, they occur perhaps on an average once a year on some part of the Gulf coast, and in one of the three months, August, September and October. To the hurricanes quoted in the chapter on General Storms from Gayarre's History of Louisiana, there may here be added a notice of the two in 1779 and 1780 by William Dunbar, in a paper on the Climate of Louisiana in volume 11 of the *Transactions of the American Philosophical Society*.

"August and September are usually called the hurricane months, and I believe there never happens a hurricane of great extent at any other season." "Since I have resided in this country two or three hurricanes only have ravaged New Orleans and its vicinity, and two of these occurred in August of each year, 1779 and 1780. At the first, half of the city of New Orleans was stripped of its covering, and many houses were thrown down in town and country ; no ship or vessel of any kind was to be seen on the river next morning."

He describes the severest portion of the gale to have been from east and southeast, and this to have been succeeded by "a profound and awful calm," with the singular sense of prostration, and the inelasticity of atmosphere which attend all tropical hurricanes of great violence at these moments. After "five or six minutes," of this calm the wind burst with nearly equal violence from the opposite point. The woodlands were prostrated over a large area in the vicinity of New Orleans and the Gulf; an area which Mr. Dunbar describes as about twenty-four miles in diameter, and nearly central at New Orleans. After the storm the leafless trees and shrubbery had the aspect of a winter scene. As the author of the account was at New Orleans at the time his statement is undoubtedly reliable, and the discrepancies in regard to the year of the severest storm—Gayarre assigning it to 1780, and Dunbar to 1779—are from accident in the authorities consulted by Gayarre perhaps, since Dunbar does not describe that of 1780 as particularly severe, and similar terms of description are employed in each case.

In the southwest of Texas some notice of the hurricanes is quoted from Dr. Berlandier and others in another place. They occur there as often as every second year in some measure of severity, and perhaps on every third or fourth year with extreme severity, but they are never regular in their recurrence. The inundations of the coast

are sometimes excessive, reaching "three leagues inland" in some cases, and rendering it unsafe to build on exposed points of the coast. Villages have been swept away repeatedly at these exposed points, and the shoal margin of many parts of the north shore of the Gulf exposes its coasts more than any part of the Mediterranean, or perhaps more than any other shores subject to hurricanes in either hemisphere.

Passing to the vegetable growths of the two areas we find a resemblance more decided than in many of the sensible weather phenomena, since temperature alone controls the distribution of several prominent staples on the borders of the tropics. Several of these are indifferent to the measure of atmospheric humidity. Indian corn, cotton, probably the sugar cane, and many tropical fruits are apparently so indifferent, in what concerns growth alone. The cotton plant is equally perfect, as such, in the deserts of the Gila, in Syria and Algiers, each an intensely arid atmosphere, as on the Sea Islands of the South Atlantic or the coasts of the Gulf. The fibre is often injured by excessive rains, but the plant appears not to be, and the luxuriance of growth depends almost wholly on the character of the soil. This is conspicuously true of Indian corn, and apparently so of cane. Oranges, lemons, figs, &c., are never repelled by atmospheric humidity so far as known.

In regard to fruits and vegetable growths the coast of the Gulf here and the Mediterranean basin equally mark the limit of tropical species, and as many of these flourish in favorable localities along the north coast of the Gulf, as along the north coast of the Mediterranean. There is but one locality of palms of considerable size in Europe, that near Nice and San Remo in the sheltered, narrow coast of Sardinia; it has scarcely been planted in Florida, yet there is no reason to doubt its successful growth on the lower half of the peninsula. The palmetto is abundant as far north as Charleston, and through the humid low alluvions of Alabama and Louisiana it grows as freely as in Spain and Algiers. The palms of all species are nearly equally adapted to the two districts. The sugar cane succeeds better here than near the Mediterranean, apparently because the measure of summer heat is there too low; various localities in Spain and on the south shores of the Mediterranean produce it, but it does not succeed in Italy, where the French made strenuous but unsuccessful efforts to introduce it. The limitation of tropical fruits to the peninsula of Florida and the Delta of the Mississippi, with narrow lines of sea exposure on the coasts only, is due to the occurrence of non-periodic extremes of cold in the United States of a more severe character than in Europe, by which well-grown trees are cut off. In 1765 Bartram

remarks the destruction of orange trees in Florida; in 1835 extensive plantations were destroyed, and at other less conspicuous instances great injury has been done them, so much as to discourage planting in the open grounds of the States bordering the Gulf, and where, but for these winter extremes, they would flourish luxuriantly. Much of Florida is yet unoccupied, and old plantations like that at New Smyrna have been allowed to go to decay from mere neglect. It is certain that the care bestowed on the culture of tropical fruits in the south of Europe would be repaid by an abundant measure of success on every part of the coast of the Gulf of Mexico.

The orange is still so far successful as to exist in indigenous form, as it is claimed, as far north as Alachua in Florida, and the extensive groves which prevail from this point southward along the St. Johns and at New Smyrna prove the general capacity of the climate for it, whether it is indigenous or not. It is remarkable, however, that many of these recede to the east coast of Florida, and at present are much less abundant on the west coast and borders of the Gulf. The coast of Georgia as far as Savannah is better protected against winter extremes than any part of the north shore of the Gulf from Mobile to Apalachee bay, and even to Charleston the coast is preferable to that at Mobile. The vegetation and fruits of the Gulf basin strictly, will not therefore compare so favorably with those of the Mediterranean as if the Atlantic coast to Charleston were included.*

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* In noticing the cultivated staples of tropical origin, most points of comparison between the cultivation of the Gulf districts and those of the Mediterranean will naturally be embraced. The cane, cotton, indigo and rice, are particularly limited to the districts bordering these two seas; and there are others, tobacco, hemp, and vines, which are of general distribution, yet with some relation to the first, as to central districts about which they are arranged.

It may be added here that the insecurity of tropical fruits at New Orleans, though greater than that in Florida first referred to, is still not such as to preclude cultivation entirely. Care in preserving these against extremes in some cases, and prompt replanting in case of injury, gives a large capacity for oranges, lemons, figs, &c., in lower Louisiana. Gayarre mentions (*Hist. La.*, p. 74), among the early difficulties of this colony and the losses falling on its cultivators, the severity of the winter of 1772, in which "all the orange trees perished, as in 1748 and in 1768." The growth of native species of the olive, orange, and palm, as they are substantially, is proof that some important measure of natural adaptation to these genera of tropical fruits exists in the southern States. A wild olive (*Olea Americana*) grows along the coasts of the Carolinas and further southward, which Michaux asserts is capable of resisting greater cold than the cultivated species; its fruit is worthless, but it might perhaps be made the basis of improved adaptation to the climate. The cabbage-tree palm forms much of the growth of the same localities; and the wild orange, which Michaux asserts is native at Vera Cruz and in Mexico, as well as at most of the larger West India Islands —at Orange Bay, Jamaica, the sweet and sour varieties both existing in perfection as natives—together afford strong evidence that the causes of failure in introducing these

The numerical elements of comparison add something to the descriptions which have been given, but for transition climates these elements do not always signify differences which are practically developed. The average temperatures in Sicily and in the south of Texas will not differ largely, yet the sensible climate is contrasted in some points quite decidedly, and in others it fully corresponds. The following mean temperatures will afford some comparison.

	Lat.	Jan.	July.	Spring.	Sum.	Aut.	Wint.	Year.
	° ′	°	°	°	°	°	°	°
Catania, Sicily	37 30	49.3	86.5	62.9	84 6	69 4	52.8	67.4
Matamoras, Fort Brown	25 54	60.4	84.2	74.7	83.6	74.6	62.1	73.7
San Antonio, Texas	29 25	53.2	83.9*	69.7	82.2	71.3	53.9	69.2
New Orleans	30 00	55.3	82.9	69.9	82.3	70.7	56.5	69.8
Tunis, Africa	36 48	53.1	79.2	64.9	83.0	71.3	55.7	68.8
Cairo, Egypt	30 02	58.1	85.8	73.6	85.1	71.5	58.5	72.2
Pensacola, Florida	30 18	53.6	82.3	68.6	81.6	69.8	54.9	68.7
Fort Brooke, "	28 00	61.5	80.7	72.1	80.2	73.1	62.3	71.9
Nice, Sardinia	43 41	44.5	73.9*	55.9	71.8	61.6	46.4	58.9
Mobile, Ala. (Ars'l)	31 12	50.4	79.8*	57.0	78.8	65.8	51.7	65.8
Beirout, Syria	33 50	54.0	82.1*	65.3	79.4	68.4	56.3	69.3
Fort Merrill, Texas	28 17	54.8	84.4*	73.9	83.2	72.2	56.3	71.4
Ringgold B'ks "	26 23	58.4	86.1*	76.6	85.3	74.5	60.4	74.2

All these stations have very high temperatures, but a single grade below those belonging to recognized tropical positions. At Nice there is an exception, however, and it appears extraordinary in connection with the known adaptation of that part of the Mediterranean coast to tropical fruits, and even to palms. Several localities between Nice and Genoa produce palm trees equal to those of the Delta of the Nile, though these are, probably, particularly warm and sheltered spots, very much favored by the local configuration, and, in addition, favored by the generally equable character of the climate of that coast in regard to great extremes of cold. At Genoa the mean temperature of summer is 75°, and of the year 61°; at Marseilles 72°.9 and 58°.3 respectively,—both of which confirm the low summer temperature

fruits and cultivating them extensively here, do not belong to climate so much as to other conditions. Difficulties of soil, and the greater profit of field staples which go to distant markets, are foremost in preventing the diversified attention to fruit culture which has long since developed and applied the most extreme capacity of every part of Europe.

Ramsay (Views of South Carolina, vol. 11, p. 52, Charleston, 1809) says of South Carolina in 1807. "It is remarkable that oranges, though plentiful 40 or 50 years ago, are now raised with difficulty. Once in eight or ten years a severe winter destroys the trees on which they grow. Of this kind are the winters of 1766, 1779, 1786, and 1796." The change he infers to have occurred is probably one of the thousand fallacious views in regard to change of climate, but the interval between destructive frosts appears, as he says, to average about ten years.

* August, the warmest month.

observed at Nice, in the immediate vicinity of which the richest growths of oranges and other tropical fruits are found.*

In the southwest of Texas the area bounded by San Antonio and Fort Brown or Matamoras gives temperatures equal to those of the Delta of the Nile, represented by Cairo. Along the Rio Grande they are higher as high up as Laredo, or for two degrees of latitude above the mouth of that river; and at several posts along the Nueces they are at the average for Lower Egypt on the Mediterranean. Forts Merrill and Ewell, with Corpus Christi on the Gulf of Mexico, have an average of 83°.5 for the summer, and 71° to 71°.5 for the yearly mean. But the extremes of cold belonging to the winter months reduce the general climatological effect much, and place it below Egypt in capacity for tropical fruits and staples. Even at Matamoras, though four degrees of latitude south of Cairo, severe frosts occur in almost every winter. The following extremes of cold are from observations at the United States military posts.

	1849	1850	1851	1852	1853	1854
Fort Brown, Brownsville	34°	22° Dec.	28°	22° Jan.	30°	30° Jan.
Laredo, Fort McIntosh	32	18 "	23	19 "	28	24 "
San Antonio	25	17 "	26	14 "	—	—

Though there are no satisfactory observations in Lower Egypt with which to compare these, it is known negatively that the thermometer never falls to the freezing point there, and that frosts are unknown. The tropical fruits and trees are therefore very much restricted on the Rio Grande, though the average temperatures exceed those at Cairo; snow is unknown at Cairo, also: at Brownsville or Matamoras it has occurred twice in five years, in Jan. 1847, and Dec. 1850, and at an average of once annually at Laredo and Corpus Christi.

The productions of this extreme southern position correspond more nearly to those of Spain and the Barbary States than to those of Egypt, with which its position at sea level, and on the coast of a gulf at the mouth of a great river, would have some correspondence. The south

* *Silliman's Tour.* Speaking of the vicinity of San Remo, a few miles from Nice along the rocky and narrow coast, Silliman says: "Palm trees appeared and soon became very numerous; many of them were lofty, 30 to 40 feet high, and very beautiful. The palm, anciently introduced from Palestine, has become naturalized here. It is the date-palm, and excellent dates were served to us at table. The recurrence of the date-palm at this place forms a singular anomaly in the geographical distribution of plants, as it is not found elsewhere in all Italy, and, with some slight exceptions on the island of Sicily, not again north of the African coast. The flora of this spot is equally tropical in other respects, a fact due, as has been suggested, to the peculiar conformation of the coast where the peninsula of Italy meets the main land, forming an angle protected by the lofty Maritime Alps from the north wind, and receiving, as in an eddy, the prevalent warm breezes from the African continent." (Vol. i. p. 235.)

of Florida alone gives as soft a climate for the winter as that of the south coasts of the Mediterranean, and at a point far enough south to do so, the tropical features of a dry winter and rainy summer become instituted. At Tampa Bay (Fort Brooke) the average temperatures are nearly those of Cairo, and the difference of latitude two degrees; yet here the winter temperature frequently falls to 30°, and the *average* of the annual minima for twelve years is 34°.4. In 1843, 1849, and 1852 the thermometer fell to 30°; in 1835 it fell at Fort King, Florida, one degree of latitude farther north, to 11°, or 21° below the freezing point. These extremes are too severe to permit the natural result of the average temperatures to appear in the vegetable growths, and we find no part of the shores of the Gulf of Mexico, except the southern point of the Florida peninsula, to correspond with the most favored districts of the south shore of the Mediterranean, though the Deltas of the Mississippi and the Nile nearly correspond in latitude. By reference to the table of minimum temperatures it will be seen that the average minimum at New Orleans is 28°, and the absolute minimum for twenty years 13°; snow falls here at an average once annually also.

It is apparent that with protection against non-periodic extremes of cold occurring at distant intervals the borders of the Gulf of Mexico in many places would show an adaptation to many tropical fruits not now cultivated, and it would not be difficult to devise means for affording this protection. With protection in 1835 the orange groves of Florida would have flourished through a period of several years, perhaps until 1852 or 1856. In the winters of the last named years more or less injury was done, but none so general as in 1835. It is probably in consequence of these irregular instances of severity that these growths are not more abundant as native products, and that Texas, with its highest temperatures, produces the palmetto, live oak, and thorny acacias only, resembling Spain and the Barbary States at a much higher latitude.

IX. DISTRIBUTION OF HEAT IN THE UNITED STATES, MONTHLY AND FOR THE SEASONS; WITH EXPLANATION OF THE ISOTHERMAL CHARTS.

THE distribution of heat is the controlling condition of all climates; and the basis of climatological distinctions of every sort. It is necessary for this reason to make the definition of the measure observed for any period, something more definite and tangible than even a numerical quantity, and though the representation of heat as a positive geographical fact is one quite difficult to make intelligible and familiar, there is no alternative but to make the attempt. Such is the necessity which originated the use of Isothermal Lines, and they mean more than the generalization on this distribution which they have usually been taken for, and really constitute a new department of physical geography. The definition of zones, which was long in vogue, has really no place in nature, and the actual measures of heat alone constitute the various belts of climate. With the variable surface and continental position of the temperate latitudes no definition is possible except from actual measurement, and the belts actually vary much more than could be inferred from any theory—at the Pacific coast of this continent in a manner incredible if the statistics were not so abundant and conclusive. A summer heat of the fiercest character, as at Fort Miller, San Joaquin Valley, California, is but a few miles removed from a summer of even more extreme refrigeration—cold enough to require winter clothing at the midday of the summer. Both these points are constant, or fixed, and not less important as physical facts than the presence of the mountains of the vicinity. To give these measures of heat a permanent form for the temperate latitudes requires an *actual survey*, as it may be called, of every considerable district, and the accumulation of the statistical elements of thermometric observation. Though the Isothermal lines may appear an arbitrary or artificial mode of representation, they are in truth less artificial than the measures of temperature, since the nomenclature of the thermometer is wholly artificial. If the differing degrees of heat were represented by tints of differing strength, from the lightest at the

coldest regions, to the deepest at the tropics, the illustration would be most nearly natural, and the thermal lines might be shaded in imitation of this gradation. But the use of simple lines was initiated by Humboldt, and they have now become so far familiarized to the public eye, as well as to special scientific representation, as perhaps to need no farther simplification. The effort to accept the illustration as a physical fact is often necessary, however, and it should be constantly exercised until the significance of lines representing the measure of heat are as plain and familiar as the simplest geography.

In representing the distribution of heat over the temperate latitudes of this continent a special explanation and discussion of each chart is necessary, comparing the quantities assigned to various districts, and showing the application of the statistics to be correct, while the solution or reasons in support of the illustration are also given. The sections of this division of the work are therefore applied to each season which is made the subject of chart illustration. Dove has constructed charts for each month, and that course would be of unusual interest and value for the United States on the large scale of the present charts. But such a representation cannot now be made, and for other than scientific purposes simply, it would be quite unnecessary. Our custom of division of the year into seasons of three months each applies to nearly all parts of the United States, and such definitions are readily understood even in their application to single months.

MEAN DISTRIBUTION OF HEAT FOR THE THREE MONTHS OF SPRING.

The entire thermal illustration is drawn from mean quantities only, determined from as many single elements, as the single observations and means for single months may be called, as may be condensed into the final mean which is used as the best approximation to positive and unalterable quantities. The distribution represented in these charts is in nearly all cases the mean distribution, and not that belonging to any single year. It should be designated as such to preclude the idea of limited periods, and the irregularity of successive years.

The distribution of heat for the three months of spring is marked by great variability in successive years, great constant differences of the months, and equally great diversity among the various districts. The measures for the whole period are for this reason less of the nature of a positive single quantity than those for summer and winter, and

WEST FROM GREENWICH
GREAT BASIN OF THE INTERIOR
PLAINS OF THE
LLANO ESTACADO
MAPIMI DESERT
MEAN SEA TEMPERATURES IN SPRING
For areas of 5° lat. & long. each W from S. Francisco
Lat. 40°
Lat. 30°
140°
130°
120° W Long.
EXPLANATION OF ISOTHERMALS.
Lines of mean temp. differing five degrees
d° d° doubtful position
d° d° differing less than 5° from the next
Minimum or lowest position of an isothermal
Maximum or most Northern position of an isothermal


ISOTHERMAL CHART
MEAN DISTRIBUTION OF HEAT FOR THE SPRING
ON THE
NORTH AMERICAN CONTINENT
BETWEEN 25° AND 50° N LAT
BY LORIN BLODGET
Scale of Statute Miles.
WEST FROM GREENWICH
NEWFOUNDLAND
NOVA SCOTIA
BERMUDAS
NEW YORK
PENN
OHIO
IND
ILL
IOWA
NEB
KAN
MO.
KY.
TENN
VIRG
N.C.
S.C.
GEO
ALA
MISS.
LA.
ARK
TEX
FLA
MICH
WISC.
MINN
MAINE
MASS
CONN
DEL.
MD.
NEW MEX.
IND T
LLANO ESTACADO
MAPIMI DESERT
BAHAMAS
M T 40°
M T 45°
M T 50°
M T 55°
M T 60°
M T 65°
M T 70°
MEAN TEMP 33°
M.T. 15 March
M.T. 65° for June
Minimum of 65°
Minimum of 55°
Maximum of 45°
Min. of 35°
70°
75°
105°
100°
95°
90°
85°
80°
75°
70°
65°
60°
55°
50°
45°
40°
35°
30°
25°

the comparison of single months is less direct for the various districts. In some parts of the territory March is a full winter month, and in others May is one fully belonging to the summer. In some general districts, as on the Pacific coasts south of the 40th parallel, the measure of heat changes very little from March to May, and in others, as in the northern interior, they differ extremely. In Minnesota the average difference of the two months is 28°, and at Lake Winnipeg 37°, while at San Diego it is but 7°, and at San Francisco 3°. In most parts of the United States, however, March shows a considerable advance in mean temperature from February, and April and May uniform differences, April dividing the extremes quite equally, and representing the mean of the three. When this is the case the season may be defined as a single period, and the measures may be taken as constant quantities for any form of illustration.

As a whole the western half of the continent is much the warmest for these months, and if the mountain plateaus did not intervene, the isothermals would be quite uniform in their course across the continent from west-northwest to east-southeast, without alteration for altitudes below 4000 feet. The district of the great lakes would make some curvatures of these lines, however, as they are then colder than the average land surface at their latitudes, and a great accession of heat occurs on the plains at both sides of the Rocky Mountains, which, if considered a part of the regular extension of the lines, would require that the somewhat cooler coast of the Pacific be considered as anomalous. All the measurements at considerable altitudes in the interior show that the element of altitude has far less influence here than in Europe.

The relation of the land temperatures simply, and those of the interior, to those of the Atlantic and Pacific coasts, shows less of contrast at this season than in summer. At the Atlantic coast the lines would extend seaward without curvature to the Gulf Stream, but they would then curve northward in its course, and rise rapidly in latitude. The position of the Gulf Stream is sufficiently known to render the recognition of its influence easy at all times, and it is always warmer than the adjacent parts of the sea, though contrasting most with the land surface of the United States in the colder months.

In May the sea within the Gulf stream is much colder than the continent generally, as the movement of drift ice and cold currents from the Arctic seas is then more decided than in the preceding months, while in March the northern portion, at least, is relatively much warmer. The mean of 32° for this last month has its position in the southern part of New England and New York, and it extends along most of the coast of Maine, and at sea in the direction of the southern extremity of Newfoundland, passing this point at a short

distance from the land, in the narrow belt which lies between the land and the warm atmosphere of the Gulf stream. The observations which have been made at Halifax and at St. Johns, Newfoundland, indicate the existence of influences greatly depressing the temperature of April and May, and rendering the mean for the whole season below that of the same latitudes inland. The mean of five years' observation at St. Johns gives 32°.3 as the spring temperature, while at Albion Mines, Nova Scotia, the mean for ten years is 37°.6*, and at the more northern military posts, Forts Kent and Fairfield, it is above 35°.

The course of the isothermals of the higher latitudes of the chart is nearly due west from the Atlantic coast, except where local divergence from this line is caused by the Lakes, to the meridian of Fort Snelling, where the lines from 45° to 30°, inclusive, make remarkable curvatures northward over the northwestern plains. The statistics of the military posts at present only indicate this result generally, and the observations of the military surveys, and at the posts of the Hudson's Bay Company have been relied upon for definite positions here. The valley and plains of the Saskatchawan river are shown by Richardson to have a much higher temperature than the districts east in the same or even in lower latitudes; the south branch of this river, in latitude 51°, being distinguished by an early and rapid advance of temperature, giving a mean for May even greater than that observed in the vicinity of the great lakes generally. The observations at Fort Benton, Fort Pierre, and Fort Laramie confirm these positions sufficiently to render this apparent anomaly clearly an established fact of distribution. The higher temperatures in these districts belong to each of the spring months in nearly the same degree, and they will appear less extraordinary if we could suppose the great altitudes of the Rocky Mountains removed, and a configuration there similar to that of western Europe.

On the Pacific coast, as on the Atlantic, a considerable falling off from the land temperatures occurs, especially in the last month. For the mean of the three months, the sea temperatures observed off this

* From the observations of Henry Poole, Esq., Superintendent of Mines. Dove gives observations at Halifax, N. S., with a mean of but 32° for the spring, but they appear inaccurate, and embrace but two years. In his essay on isothermal lines he remarks particularly the effect of drift ice in depressing the temperature of this coast in April and May, and the crowding of the thermal lines between the Gulf stream and the coast. The general refrigeration of the air, and the intrusion of warmer volumes at times is strikingly shown in the frequency of ice formation on the trees, and in the dense and almost constant fogs. For these months the isothermals are drawn by him with sharp depressions about Newfoundland and its vicinity.

coast are strikingly uniform, and they show but little if any advance on those of winter. For some hundreds of miles, on the 40th parallel, there is very little difference in the sea temperatures for the entire year; and in spring such observations as we possess show them to be quite the same between the 35th and 40th parallels for thirty degrees of longitude westward from San Francisco. The observations given in Maury's Charts furnish about twenty measurements for each area of five degrees extent, in both latitude and longitude, and the means are 56° to the 125th meridian, 55°.4 to the 130th, 55°.5 to the 135th, 56°.4 to the 140th, 57°.2 to the 145th, and 56° for the last observed area, bounded on the west by the meridian of 150° west longitude. These successive results are substantially identical, and they confirm the records at the military posts of the coast, explaining the cause of the singular contrast of their temperatures with those of the interior, in showing very little increase of heat as the summer approaches. It will be seen by reference to the analysis of the summer distribution, that the sea then remains nearly at the same temperature for seven or eight degrees of longitude off the coast, while beyond that point it shows some increase of heat for May, and a rapid change for the months of summer. From this evidence the isothermals would, apparently, extend in right lines westward, on leaving the coast in spring, while in summer they curve abruptly northward, after passing the cold mass of water. The Pacific climates appear to be distinguished for the *identity of the air and water temperatures*, so far as observed, at least the differences are so small that it is not necessary to separate them in the purpose of this comparison.

By reference to the Isothermal Chart for spring the advance in temperature from April, or the mean of the three months, to May, is seen to be very little for the immediate coast, the line of 55° leaving it near Monterey in both cases. The same line for March differs most from any other, as this is but little north of San Diego at its point of departure from the coast. The measure of difference of these extreme positions is, however, less than three degrees of latitude, while in the Mississippi valley the mean of 55° for March falls southward of Fort Towson, to 33° of latitude, and rises in May above Fort Snelling, to latitude 46°—a range of thirteen degrees, divided quite equally by its mean position at St. Louis.

The cause of this peculiar uniformity of temperature on the Pacific coast will again be referred to in connection with the summer distribution, as it then attains its maximum influence, and its characteristics may be more readily recognized.

The relation of the spring temperatures of the interior of northern Mexico to those of the adjacent districts of the United States cannot

be noticed for want of observations there. A large area of dry basins south of the Rio Grande, and extending from El Paso, with some interruptions, to the Gulf of Mexico, is warm at all seasons, and the isothermals of the Rio Grande above Fort McIntosh may usually be continued northwestward, at least across the Bolson de Mapimi. The mountainous districts south and westward of these basins are relatively warmer in spring than in summer, though none of this interior probably attains the temperatures, either in spring or summer, of the Lower Rio Grande and Colorado valleys. The temperature at Vera Cruz for the spring is 77°, and there is probably no part of the coasts of Mexico northward which exceeds this, and few which attain the mean of 75°, observed at Fort Yuma and the military posts of the Lower Rio Grande.

In the West India islands the spring temperature is above that at Key West, though the southern portion of Florida is tropical; the mean at Havana and other points being 78° to 79°.5. There is probably no point, therefore, where the land temperature exceeds that of the sea southward, or of the Gulf of Mexico, though they differ very little for the warmer positions named.

The principal lines of the Isothermal Chart differ five degrees in temperature, and east of the meridian of 100° they divide distance on the meridians with great uniformity. On the Atlantic side the range is thirty-five degrees of temperature for twenty-two degrees of latitude, or, excluding the lower part of the peninsula of Florida, thirty degrees of temperature for seventeen of latitude, which is very nearly a decrease of temperature of one degree for forty miles of distance northward. The same decrease is found in the Mississippi valley, and on both these lines the altitude does not attain sufficient importance to sensibly affect this result. The Pacific side is too irregular to give comparable measures, but from the parallel of 30° to Astoria, the same distance which was taken in the first case, there is but one-third the difference in temperature, or one degree for one hundred and twenty miles northing. If the comparison were carried to Sitka, latitude 57°, but five degrees of temperature more are lost, and the same proportion or rate of diminution is still maintained.

The relation of the differences separating the isothermals of the principal portion of the continent east of the Rocky Mountains is such that the successive months of spring would remove one to very near the position of another, and the mean of 65° for May, of 55° for April, and of 45° for March, would occupy nearly the same position. The lines as drawn are quite correct representatives of the temperature of April. To place on these the temperatures of May the line of 60° becomes 70°, that of 55° becomes 65°, &c.; and the reverse if March is illustrated. This feature of the temperature distribution for

these months will be better understood by reference to the following measures of increase of heat through the spring months at several stations. The quantities given are the differences from March to April, April to May, and May to June, all taken from the mean results of the series.

In the south these measures of difference are less, and in the northwest they are greater than ten degrees, but for much the largest portion of the area east of the plains this number would indicate the march of temperature in these months quite correctly. The differences at the posts of the Pacific coast and at some European stations will illustrate the contrast presented in this season there:

Stations.	Mean of Mar.	Mar. to Ap.	Ap. to May.	May to June.
Albion Mines, N. S.	27.1	10.2	11.2	9.8
Portland, Me.	32.5	10.4	9.9	10.3
Boston	36.2	10.2	10.1	9.7
New York	38.3	10.4	10.7	9.0
Toronto	30.4	10.9	10.2	9.9
Philadelphia	40.3	10.3	10.9	10.4
Baltimore	42.3	10.4	10.4	8.6
Fort Washington	46.8	10.3	11.1	8.1
Chapel Hill	51.1	8.5	7.5	7.5
Augusta Arsenal	55.8	9.3	7.0	7.0
Charleston	58.7	6.7	8.0	6.0
Key West	72.9	2.5	3.7	2.5
Pensacola	61.8	6.7	6.9	5.4
New Orleans	61.6	6.2	6.2	4.7
Fort Gibson	52.2	8.8	8.1	7.7
St. Louis	42.3	12.7	10.0	9.2
Cincinnati	43.5	10.6	9.5	7.8
Detroit	35.4	10.8	9.8	9.6
Fort Howard, Wisc.	31.3	12.1	12.3	10.3
Fort Snelling	31.4	14.9	12.6	9.5
Fort Leavenworth	42.2	13.3	8.2	7.7
Fort Laramie	36.8	10.8	8.5	11.2
San Diego, Cal.	56.0	5.2	1.5	4.6
San Francisco, Cal.	52.8	2.5	0.0	3.5
Fort Vancouver	44.1	8.4	6.4	3.7
Fort Miller, Cal.	56.7	6.2	6.0	4.9
Fort Yuma, Cal.	66.1	7.3	4.3	10.5
Santa Fé, New Mex.	40.7	10.5	5.8	11.8
Fort Massachusetts, N. M.	31.3	13.6	4.6	8.8
London, England	42.5	4.4	6.6	7.0
Dublin	43.2	4.8	6.3	5.9
Paris	44.0	5.7	9.6	4.6
Berlin	38.1	9.3	9.1	6.8
St. Petersburg	25.5	11.6	11.4	11.4
Sebastopol	42.3	8.6	10.6	10.5
Barnaoul, Russia in Asia	9.2	24.1	17.4	11.0
Pekin, China	43.1	13.1	11.1	7.3
Norway House, Brit. Amer.	7.0	20.1	17.5	10.3
Boothia Felix, Brit. Amer.	—28.7	26.2	18.2	18.5

These comparisons show that the advance of temperature in spring is quite uniform through the three months, and that the central areas of the United States correspond with Germany and Central Europe in this respect. From March to April and from April to May the advance is more regular than in the approach to the mean for March and to that for June. In short, the uniformity of the advance in temperature belongs to a less period than three months in the continental climates. The least advance belongs to the coast of California, and it has been alluded to already to some extent. Even the interior posts of Yuma and Miller, where excessive heats prevail in summer, show a less rapid march of temperature in spring than the Atlantic posts. The more elevated district of New Mexico alone exhibits the characteristics of a continental climate in this respect. The modified climates of Western Europe appear in the measures for London, Paris, &c., and at Moscow and Barnaoul, European and Asiatic Russia, the great measures of difference belonging to the most extreme continental climates appear. Fort Ripley gives the most extreme measures observed at any point in the United States, and the Arctic regions of British America alone exhibit the differences which are found in the interior of Asia, but which are there connected with much higher absolute temperatures.

The district of most rapid advance of temperature in spring in the United States has also a comparatively high temperature for the month of March, so that the transition to summer is completed before June. At Council Bluffs March is warmer than at Fort Sullivan, and the difference between this month and April is twice as great at the former post. The average of twenty degrees advance in the two months at eastern stations generally corresponds to an average of twenty-eight for a large area central at Fort Snelling, and an average of twenty-five degrees for a still larger area surrounding this, and reaching to the lakes on the east, to St. Louis and Fort Kearny, and to near the sources of the Missouri northwestward. The greatest mean advance is of eighteen degrees for thirty days, or six-tenths of a degree daily.

The irregular non-periodic distribution of heat for the spring is a feature of great practical as well as scientific importance, and it presents more noticeable points, which do not appear in the determined mean temperatures, than any other part of the year. Some of the more prominent of these appear in the comparison of the means for the same month, and of the same season for successive years; and some measures of the last named variation are illustrated in the isothermal charts by the lines representing the maximum and minimum positions of an isothermal of any degree. The areas east of the Rocky Mountains only could be intelligibly illustrated in this manner, as the periods

at the newer of the posts are insufficient to show whether the entire measure of range is embraced. This period is ample for the older posts, however, as a series of fifty years since 1800, and detached series previous to that date from 1743, exhibit no extremes greater than the low temperature of 1843 and the high temperature of 1842 for the spring. Extremes scarcely less than these fall between the years 1830 and 1840 in some limited districts.

As illustrated by the lines of the chart, the minimum of any degree is designed to represent the extreme point to which the temperature of any locality on the line may fall in any year, and not the lowest position of the line in any single year for the whole area. The lowest point observed in the Mississippi valley rarely occurs at the same time that the greatest extreme falls on the Atlantic coast; the lines are, therefore, the measures of *maximum variability* at each point. Comparing these measures on the Atlantic coast, the range of the mean of 45° is from Fort Mifflin to Hancock Barracks, about seven degrees of latitude, and somewhat more above, or north of its mean position, than south of it. In the west its greatest range is from near Fort Ripley to a point midway between Fort Leavenworth and Fort Scott, one of these last giving 42°.5, and the other 47°.5 as the minimum in 1843, and the short period at Fort Ripley giving 42°.5 as the maximum in 1855. The measure of range at Fort Snelling is 5°.2 above the mean in 1825, and 12°.1 below it in 1843. The same measure of range would give a maximum of 45° at Fort Ripley, and the range of this isothermal, as thus defined, is over nearly nine degrees of latitude, or more than six hundred miles. The range in distance is no greater than this on the western border of the Plains, apparently, though the isothermals are much more widely separated there, as the variation of temperatures in successive years is certainly much less. As a possible transfer of the mean temperature of an entire season, the measure for all parts of the eastern and central areas is certainly very great, and it has no parallel at the European stations where the same period has been observed and the comparison may be fairly made.

The maximum and minimum position of other lines between 40° and 65° has nearly the same measure of range, diminishing, however, towards both extremes. There is some conformity to a rule placing a minimum of any degree in the position of a mean of five degrees greater, and a maximum on a mean of five degrees less;—thus the maximum of 45° is nearly identical with the mean of 40°, and the minimum of 55° with the mean of 60°. One decided exception to this is found in the greater depression of the minima of 40° and 45° in the Mississippi valley, or the greater separation of these from the

mean lines which they elsewhere so nearly follow. The greater depressions of temperature, as well as the greater heats here, attain their most extreme measures, as may be seen in the record for 1843 particularly.

On the Pacific coast the measures of variation would, from analogy, be much less, and the limited period of observation gives insufficient data for illustrating this feature of variability. At Fort Steilacoom, for six years, the greatest range is 2°.5, at Fort Vancouver 2°.5, at San Francisco 3°, at Benicia 4°.5, and at San Diego 4°.5—the same six years, 1850 to 1855, giving 8° variation at Fort Snelling, 11° at Fort Leavenworth, 5° at Pittsburg, and 4°.6 at New York. In New Mexico the range for the few years observed appears to be large, yet the observations are not entirely reliable at Fort Fillmore and Albuquerque, where the greatest differences, of 10° and of 6°.7, occur, the extreme years being 1852 and 1855.

In the lower portions of Texas and Florida, districts approaching tropical temperatures, the former gives a range of 4°.5 at two or three posts—Fort McIntosh and Ringgold Barracks—for the last six years, and the latter a much less range, or but 1°.5 in the latitude of Fort Brooke, and but 2° at Key West. At two or three posts in Florida a sufficiently extended series of years has been observed to give the probable extremes of the spring temperature there, and from these 1838 and 1843 appear to have given the lowest temperatures, which were 4°.5 below the mean at St. Augustine, 3°.5 at Fort Brooke, and 2°.1 at Key West. The highest were in 1826 at the first two localities, and in 1854 at Key West, the difference being 5°.8, 3°.6, and 1°.8 respectively. The range in Northern Florida and Texas shows a measure of variability in the spring temperatures which identifies these districts with those having continental climates, notwithstanding their high temperature.

The range of the mean temperatures of single months is much greater than might be anticipated from the measures just given, and two or three representative stations may be cited which will sufficiently show what it is. At West Point the range for March is 20° between 1842 and 1843, at Watervliet 17° for the same dates, at Alleghany Arsenal 20°.7, at Cincinnati 23°.6, at Detroit 22°.5, at Fort Brady 18°.1, at Fort Crawford, 25°.7, and at Fort Snelling 34°.5—in each series here cited these years presenting both extremes in much greater degree than any others observed. In lower latitudes Norfolk gives 20°.1 as the variation for the same dates, Fort Marion 14°.6, Mobile 18°.9, New Orleans 19°.3, Fort Towson 26°.1, Fort Gibson 23°, and St. Louis 33°.2. In lower Florida, Fort Brooke gives 10°.3, but Key West unfortunately was not observed. In nearly all the tables of the longer

periods the years 1842 and 1843 give the extreme measures of the series, and the highest measure is generally at the mean temperature of the next month, April, while the lowest, in 1843, is several degrees below the mean of January in every case. This is an instance of the oscillations characteristic of American temperature range, where the extreme depressions go much farther below the averages than the extreme heats rise above them—the fall of temperature in the present case at Fort Snelling being 26°.8, while the excess of the warm extreme was but 7°.7. For several posts near Fort Snelling the absolute mean of March for 1843 was but two or three degrees above the lowest temperatures of any winter month.

The range of mean temperature in April and May is much less, that for April at Fort Snelling being 22°, or eleven degrees below in 1850, and eleven above in 1839. At Fort Leavenworth the same dates give 18°.5 of range, at Fort Howard 15°, Alleghany Arsenal 15°, West Point 12°, and Fort Sullivan 10°. The variability remains large, however, at southern posts; at Fort Monroe 12°, St. Augustine 10°, Fort Brooke 6°, and New Orleans 7°.5. There are no conspicuous years giving extremes which extend over the whole area.

The following table will give a sufficient number of these citations in tabular form to enable any one to recognize the principal features of this division of temperature distribution.

General Range of Mean Temperatures in the Spring Months.

	MARCH.					APRIL.					MAY.				
	Highest mean temperature.	Lowest mean temperature.	Range.	Date of maximum.	Date of minimum.	Highest mean temperature.	Lowest mean temperature.	Range.	Date of maximum.	Date of minimum.	Highest mean temperature.	Lowest mean temperature.	Range.	Date of maximum.	Date of minimum.
Fort Snelling	39°.1	4°.7	34°.5	1842	1843	57°.3	35°.4	21°.9	1839	1850	68°.2	51°.9	16°.3	1829	1842
Fort Leavenworth	53.4	17.4	36.0	1842	1843	64.0	45.5	18.9	1839	1850	67.1	59.3	7.8	1833	1837
Jefferson Barracks	58.7	25.5	33.2	1842	1843	65.6	48.5	17.1	1845	1850	73.7	57.5	16.2	1829	1838
Cincinnati	52.5	28.8	23.7	1842	1843	64.2	48.3	16.9	1844	1837	67.0	56.7	10.3	1846	1838
Fort Gibson	62.2	39.5	22.7	1842	1843	68.7	55.3	13.6	1839	1850	74.2	62.3	11.9	1829	1838
Fort Jesup	68.5	41.6	26.9	1826	1843	71.6	62.3	9.3	1823	1829	77.9	68.5	9.4	1826	1838
New Orleans	71.3	52.0	19.3	1842	1843	74.4	67.1	7.3	1840	1846	78.4	68.6	9.8	1844	1838
Fort Brooke	72.9	62.6	10.3	1826	1843	75.9	69.8	6.1	1840	1828	79.7	72.2	7.5	1826	1838
Key West	76.5	70.2	6.3	1854	1855	78.1	73.1	5.0	1843	1837	81.2	77.0	4.2	1843	1838
Fort Moultrie	64.0	48.8	15.2	1828	1843	69.3	61.9	7.4	1826	1835	77.3	66.1	11.2	1828	1829
Fort Monroe	57.2	37.1	20.1	1842	1843	62.8	51.0	11.8	1842	1850	72.2	61.6	10.6	1844	1849
Fort McHenry	47.9	30.1	17.8	1842	1843	56.9	47.4	9.5	1846	1841	70.1	55.7	14.4	1833	1841
Fort Columbus	44.6	30.3	14.3	1842	1843	53.5	44.1	9.4	1844	1838	64.9	54.4	10.5	1826	1850
Alleghany Arsenal	46.7	26.0	20.7	1842	1843	59.5	44.4	15.1	1844	1852	65.4	53.9	11.5	1842	1850
Watervliet Arsenal	42.0	25.2	16.8	1842	1843	53.4	37.2	16.2	1844	1838	67.2	53.4	13.8	1826	1850
West Point	46.7	26.7	20.0	1842	1843	54.6	42.5	12.1	1827	1838	68.1	53.5	14.6	1826	1850
Fort Constitution	39.5	26.5	13.0	1831	1843	47.6	38.7	8.9	1827	1838	59.2	48.2	11.0	1828	1837
Fort Sullivan	35.4	27.2	8.2	1831	1850	45.5	35.9	9.6	1844	1832	55.8	45.0	10.8	1831	1841
Ringgold Barracks	74.1	65.5	8.6	1854	1855	77.7	76.2	1.5	1852	1855	83.8	76.9	6.9	1851	1850
Fort McIntosh	74.2	65.3	8.9	1854	1855	78.2	74.0	4.2	1853	1850	84.5	76.4	8.1	1852	1850
San Diego	58.4	54.6	3.8	1855	1854	63.7	57.7	6.0	1855	1852	66.0	60.7	5.3	1855	1854
Benicia	56.4	50.3	6.1	1855	1854	60.1	56.1	4.0	1851	1843	61.8	56.4	5.4	1851	1854
Fort Steilacoom	50.0	37.3	12.7	1855	1850	56.6	48.1	8.5	1850	1852	60.2	57.2	3.0	1850	1854
Fort Vancouver	47.7	40.2	7.5	1855	1852	51.5	46.5	5.0	1851	1852	57.6	54.4	3.2	1853	1851

From the preceding table it will be seen that the range of variability is somewhat greater than the differences of successive months on the whole, though if the single extreme of March 1843 were removed, there would be great uniformity in these two measures of variation.

In all forms of this comparison these measures are very large, applied as they are to the mean of a period of ninety days, and they indicate the great importance which the law of non-periodic variations of temperature has in this climate.

The *average variability*, derived from the mean of the departures in *both* directions, is also an important phase, particularly at these months. It is the change which may be expected in every year; and the following selection of three principal series will give the departures for each month, as derived by comparison with the mean for the whole period, and the means and extremes of these departures:—

Series and Mean of Variations of Temperature for the Spring Months, at three principal Posts, from 1820 *to* 1854.

DATE.	NEW YORK, FORT COLUMBUS.				FORT GIBSON.*				FORT SNELLING.			
	March.	April.	May.	Spring.	March.	April.	May.	Spring	March.	April.	May.	Spring.
Mean temps.	38°.3	48°.6	59°.3	48°.7	52°.2	62°.1	68°.8	61°.0	31°.4	46°.3	59°.0	45°.6
1820	..	..	..	..	..	..	..	..	−5.0	+6.4	+1.7	+1.0
1821	..	..	..	..	..	..	..	..	−2.4	−5.7	−1.9	−3.3
1822	+3.8	+3.7	+4.0	+3.9	..	..	..	..	+6.0	−2.6	+2.3	+1.9
1823	−1.9	+1.0	−0.5	+0.4	+1.2	+4.1	+3.4	+3.0	−1.6	+2.9	−2.0	−0.2
1824	−0.8	+1.3	−1.3	−0.2	+4.5	−3.0	+2.8	+1.5	−7.6	−4.6	−2.7	−5.2
1825	+5.4	+2.7	+3.2	+3.8	+5.2	−0.5	+4.0	+3.0	+4.9	+8.9	+2.0	+5.2
1826	−0.6	−5.4	+5.6	−0.1	+9.1	+2.8	+4.2	+5.4	−1.8	−8.6	+7.8	−0.9
1827	+1.0	+3.4	+0.2	+1.6	+0.9	+2.1	−1.5	+0.5	+0.3	−1.6	+4.0	+0.9
1828	+2.5	−3.4	+0.7	−0.0	+2.5	−3.0	+2.5	+0.7	+0.8	−1.3	+1.3	+0.3
1829	−0.4	+3.6	+4.5	+2.6	−3.9	−2.6	+5.3	−0.4	−1.6	+1.7	+9.2	+3.1
1830	+2.8	+4.2	+1.0	+2.7	+5.2	+3.1	+1.1	+3.1	+2.6	+5.4	+0.8	+2.9
1831	+3.7	+1.3	+1.8	+2.4	+1.5	+2.0	−0.7	+0.6	+0.8	−1.2	+2.2	+0.6
1832	+0.7	−0.4	−3.2	−0.9	+3.0	+2.1	+0.9	+2.0	+6.6	+7.6	−3.1	+3.8
1833	−2.4	+2.7	+1.4	+0.6	−1.8	+1.8	+2.1	+0.7	+2.7	+5.4	+2.1	+3.4
1834	+1.4	−0.2	−2.8	−0.5	+0.3	+5.8	+3.5	+3.2	+0.9	+5.3	+2.8	+3.0
1835	−2.7	−2.8	−0.9	−2.1	−1.0	−1.9	+2.8	−0.0	+1.3	−2.3	+3.6	+0.9
1836	−6.0	−4.3	−1.3	−3.9	−6.1	+3.3	+2.4	−0.1	−11.2	−2.7	+5.3	−2.8
1837	−3.3	−2.6	−4.0	−3.5	−2.0	−6.4	−2.5	−3.6	−6.9	−5.0	−4.9	−5.6
1838	−0.4	−4.5	−3.2	−2.7	+1.5	+3.6	−6.5	−0.5	+6.0	−4.6	−5.9	−1.5
1839	+0.4	+1.2	−1.6	0.0	+1.5	+6.8	+2.5	+3.7	−1.8	+10.9	−1.8	+2.5
1840	+2.0	+2.8	−1.3	+1.2	+2.3	+1.4	+0.3	+1.3	+3.4	+1.2	+4.9	+3.2
1841	−0.9	−2.7	−2.8	−2.1	−0.1	−0.3	−0.6	−0.3	+1.8	−8.2	+0.8	−1.9
1842	+6.3	+2.9	−0.9	+2.8	+10.0	+2.0	+1.3	+4.5	+7.7	+3.5	−7.1	+1.4
1843	−8.0	−1.3	−0.2	−3.1	−13.7	+0.3	−1.9	−4.8	−26.8	−2.8	−6.7	−12.1
1844	+0.5	+4.9	+4.0	+3.1	−1.8	+4.2	+1.1	+1.2	+1.5	+5.1	−3.9	+0.9
1845	+3.8	+2.2	+1.2	+2.4	−1.7	+6.3	−1.8	+1.0	+3.1	+1.3	+1.9	+2.1
1846	+1.0	+1.7	+1.1	+1.3	+0.5	−0.3	+1.2	+0.5	+7.0	+0.0	+4.7	+3.9
1847	−2.3	+0.9	+0.2	−0.4	−5.2	+3.9	−3.3	−1.5	+7.6	−0.1	−6.3	−4.6
1848	−2.2	+1.5	+2.1	+1.1	+0.9	−4.8	+1.9	−0.6	−3.2	−1.6	+1.2	−1.2
1849	−0.4	−1.1	−4.3	−1.9	+3.6	−1.6	+0.1	+0.7	−1.2	−6.6	−4.2	−3.6
1850	−2.1	−4.6	−4.9	−3.8	−2.8	−6.8	−2.2	−3.9	−7.4	−10.9	−3.1	−7.8
1851	+1.5	+0.5	−1.1	+0.3	+1.9	−3.9	+3.4	+0.5	+7.9	+3.8	−1.0	+3.6
1852	−1.5	−4.9	+1.0	−1.8	+1.8	−3.3	+1.3	−0.1	−4.6	−3.3	−0.5	−2.8
1853	+1.3	−0.5	+1.0	+0.6	−2.8	+1.2	−4.0	−1.8	−8.4	−1.4	−4.0	−4.6
1854	−2.1	−3.6	+0.6	−1.7	+1.4	−1.6	−1.2	+0.5	−0.7	+2.2	−1.1	+0.2
Aver. departure	2.30	2.59	2.06	1.80	3.27	3.02	2.32	1.72	4.72	4.20	3.40	2.94
Greatest depart.	8.0	5.4	5.6	3.9	13.7	6.8	6.5	5.4	26.8	10.9	9.2	12.1
Greatest range	14.3	10.3	10.5	7.8	23.7	13.6	11.8	10.2	34.9	21.8	16.3	17.3

NOTE.—The mean departure of each month at London, by the Royal Society's observations for 65 years, as analyzed by Glaisher (*Phil. Trans.* 1849), is as follows:—

Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.
3°.17	2°.35	2°.41	2°.30	2°.08	2°.17	2°.14	1°.79	1°.88	1°.95	2°.02	2°.85

* At Fort Jesup to 1827.

The preceding table shows that the oscillations are almost constant, and that very few instances of small departure occur. The constant oscillation at Fort Snelling, for March, is 4°.7; at Fort Gibson, 3°.27; and at Fort Columbus, 2°.3. It diminishes through the other months, and for the whole period is scarcely two-thirds of the average of the single months. This indicates that the quantities extinguished in obtaining the mean of the three months, or the compensating quantities, constitute but a third of those considered, and that the variations, either in time or in degree, cover two-thirds of the period, or influence two thirds of its measure of heat. This fact also demonstrates the truth of the suggestion elsewhere made, that the period we designate as *Spring* is, on the whole, too long for identification as a single quantity in the continental temperate regions of this hemisphere. The natural seasons are unequally divided in time, in truth, the winter and summer being longer, and the spring and autumn being shorter than ninety days.*

The remaining feature of this variability is the range of single observations through these months, and particularly through April and May. An analysis which would give the mean position of these single extremes for every year, and the absolute position of each, as selected from the whole series, would best express the more desirable form of the result. Thus it is important to know to what degree we may expect the temperature to fall, at any single observation, in each of the spring months, in the several districts, or the *mean* of the minima and maxima, and, also, to know what is the very highest and very lowest point possible to be attained in a series of years. The line of 32°, as a minimum for each month, is also quite necessary in a practical climatology.

The last point, or the districts in which the thermometer generally falls to near the freezing point once or more in the course of the month, may be readily defined without a tabular statement.

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* An admirable analysis of ten years' observations at Albion Mines, Nova Scotia, has been made by their author, Henry Poole, Esq., by which it appears that the seasons there are naturally resolved into periods of 66 and 63 days for spring and autumn, and 120 and 116 days for winter and summer. The winter minimum temperature is January 20th, or thirty days after the solstice, and the summer maximum. July 22d, or thirty-one days after the solstice. The mean annual temperature is passed on May 1st and November 4th, forty-one and forty-four days after the equinoxes, respectively.

Howard (Climate of London) gives the natural seasons at London, as nearly equal in time; the spring is from March 6th to June 6th; the summer from June 7th to September 7th; autumn from September 8th to December 6th; and winter from December 7th to March 5th. "A leafing verdant spring, a flowering summer, a fruiting autumn, and a dormant, naked winter."

On the coast of California an examination of the minima for five years affords but two instances of the observation of 32° in March; while in the interior, and in Oregon, it may be anticipated several times in this month, though the lowest observed point at stations not much elevated is 19°. In April it is never reached in California at the sea level, or near it, and rarely in Oregon—at Puget's Sound three times in six years. In May there are no instances of its occurrence on the Pacific coast, except at stations elevated two thousand feet, or more. At Fort Yuma, in the valley of the Colorado, the freezing point never is reached in spring.

At all the stations of New Mexico the temperature constantly falls below 32° in every month of spring, and at Fort Massachusetts and Fort Defiance it usually does so in June.

In Texas there is no frost or ice in the lower Rio Grande valley in these months, though it twice occurs at Fort Duncan, and the posts of that vicinity, in March. Perhaps a more extended series of years would give instances of severe frost in the principal portion of this valley in March, though there could be none in the following months. All the remaining portion of Texas has the occurrence of frosts in March regularly; in April, for the lower districts, very rarely, though they occur in half the years, or more, at the posts on the plateaus elevated one thousand to two thousand feet; but never in May at any point not mountainous.

In the principal area of the United States eastward, the lower portion of the peninsula of Florida, below Fort Brooke, is the only portion not liable to frosts in March in extreme years. From the year 1822, when observations were either at that district or so near it as to decide the point, twelve years occur in which the thermometer fell to 32° or lower as far south as Fort King, and in two of these years at least, 1835 and 1843, it fell to the freezing point as far southward as Fort Brooke. In something more than half the years of the period now observed, the coast of the Gulf and of the Atlantic to Charleston experiences one or more instances of a temperature of 32° in this month.

In April the line of ice and frosts, or of temperatures at or near 32°, recedes to Fort Monroe and Fort Gibson, and they are much more rare at either of these posts than at Florida stations in March. The depressions of temperature in which they occur are, however, frequently connected with falls of snow in the Atlantic States, and they usually affect the more elevated portions of all the States east of Alabama. In 1854 a heavy fall of snow occurred at the middle of the month in Virginia, and ice was formed in the vicinity of Charleston, South Carolina. Though frosts are quite frequent in this month

at St. Louis, there are few instances of the formation of ice in the latitude of Fort Gibson; light hoar frosts occur in almost every year, however, and sometimes as far southward as Baton Rouge. These may occur at an air temperature of 43° in the ordinary positions of the thermometer.

In May the line of ice formation rises to St. Louis, Cincinnati, Philadelphia, and the posts of New York harbor, and at these points the temperature of 32° is not found in every year. Ice is formed during the first half of the month to this latitude in the interior districts, however, quite regularly, and hoar frosts occur in the remainder where the altitude is noticeable and at some distance from the coast. At the close of this month frosts disappear from all portions of the United States territory, except at the highest altitudes cultivated. In connection with the general range of temperature extremes the mean and absolute minimum temperatures for these months will be given.

The features of temperature distribution for these months are more important in every sense than those of other months, and a corresponding effort has been made to indicate clearly what they are. The comparison of the areas affected similarly or otherwise by the extremes of temperature occurring in the daily changes belongs more appropriately to the dynamics of the climate.

DISTRIBUTION OF TEMPERATURE FOR THE THREE MONTHS OF SUMMER.

The chief points of difference between the temperature distribution of the two continents of the northern hemisphere appear in the summer more decidedly than at any other season, and distinguish the isothermal illustration for this season by some extreme and apparently inexplicable curvatures. The difficulty of illustrating this distribution is increased by taking the actual superficial distribution of heat as the principle on which the chart is constructed, because of the great altitude of the plains and mountainous districts of the interior and western portions of the continent. These plains and plateaus are generally characterized by very high summer temperature also, and in the detailed examination and comparison of these districts, these altitudes, and the particular problem of vertical distribution of heat will require some notice.

Generally the summer temperatures show a great change from those of the winter months, and the interior areas which are but little elevated above the sea exhibit almost or quite unparalleled measures of heat. These warmer portions exceed even the tropical districts of

the continent in mean temperatures for these months, and they still more exceed those of the adjacent seas on the south. The mean surface temperature of the Gulf of Mexico, and of the coasts of all parts where the trade wind and sea breeze, and the tropical rains prevent any accession from the radiation of land surfaces, appears to be very nearly at the mean of eighty degrees for the summer; and the West India islands generally, at positions with the usual land surface exposures, at a mean of eighty-one and a half and eighty-two degrees for the same months.* On the tropical coasts, where the rainy season is most perfectly developed in summer, and continues most uniformly, as on the coasts and islands of Granada and the isthmus of Panama, the mean is still lower, and often as low as 78° for July.

The districts distinguished by these extra-tropical temperatures in the United States embrace the dry interior of Florida, which has a mean of eighty-two degrees or more for the summer, and a large area beginning near Savannah on the east, and extending through the whole low country of the Gulf States westward to the Rio Grande. In Texas this belt is much enlarged, and it borders on and embraces a large district in the valley of the lower Rio Grande, where the sum-

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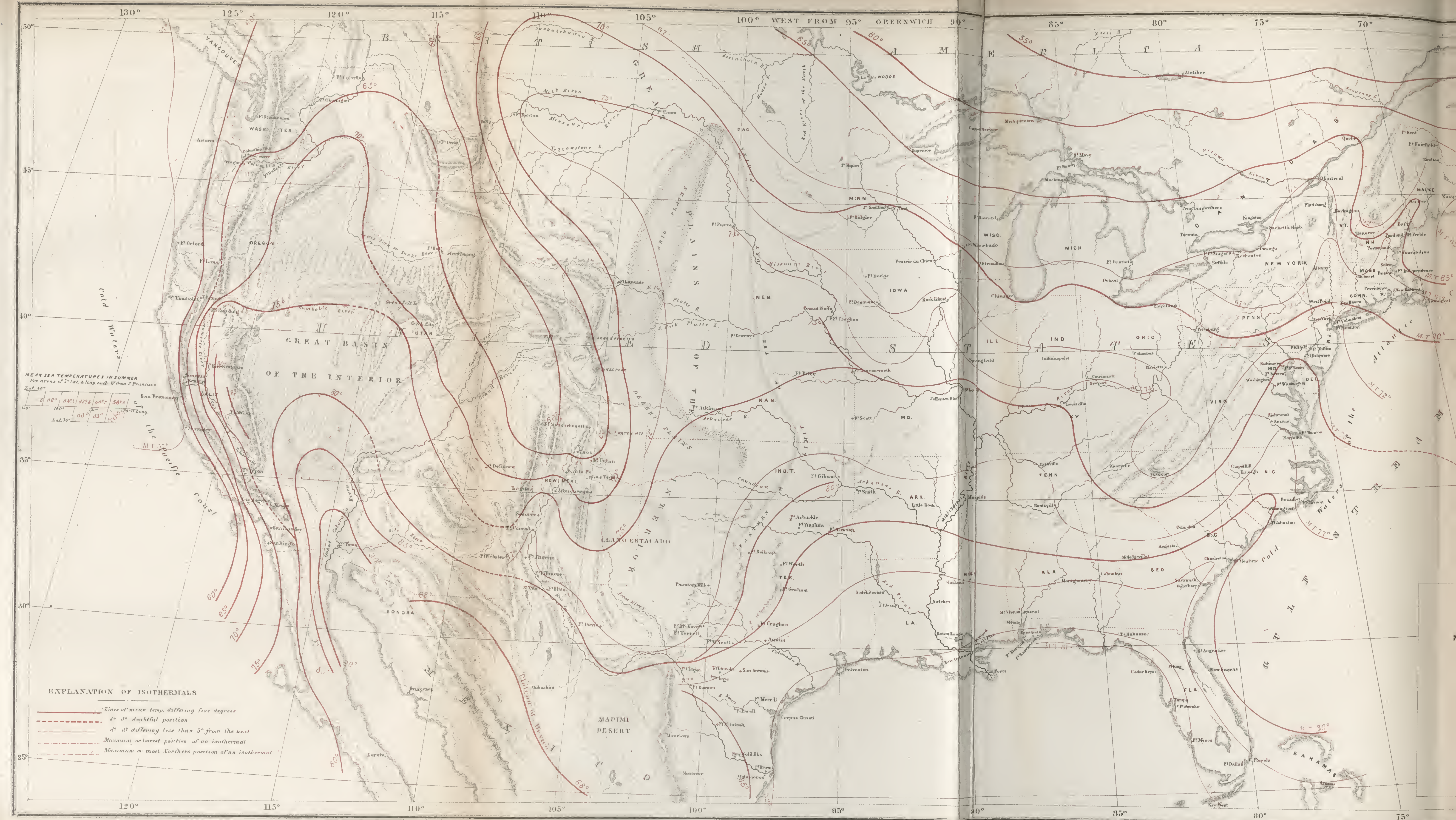
* The results of several series of observations in the West India islands correspond strikingly in the measures of mean temperature for the summer where the conditions of exposure are alike, as the following citations show:

		Degrees.
Ubajay	series of 4 years, from Humboldt	81.8
Havana	do. 8 years, from Kaemtz	81.3
Matanzas	do. 3 years do.	81.7
Jamaica	do. 5 years do.	81.3
St. Bartholomew	do. 2 years do.	81.3
Havana	do. 3 years, from Ferrer	83.3
Kingston	do. 5 years, from Lindsay	81.1

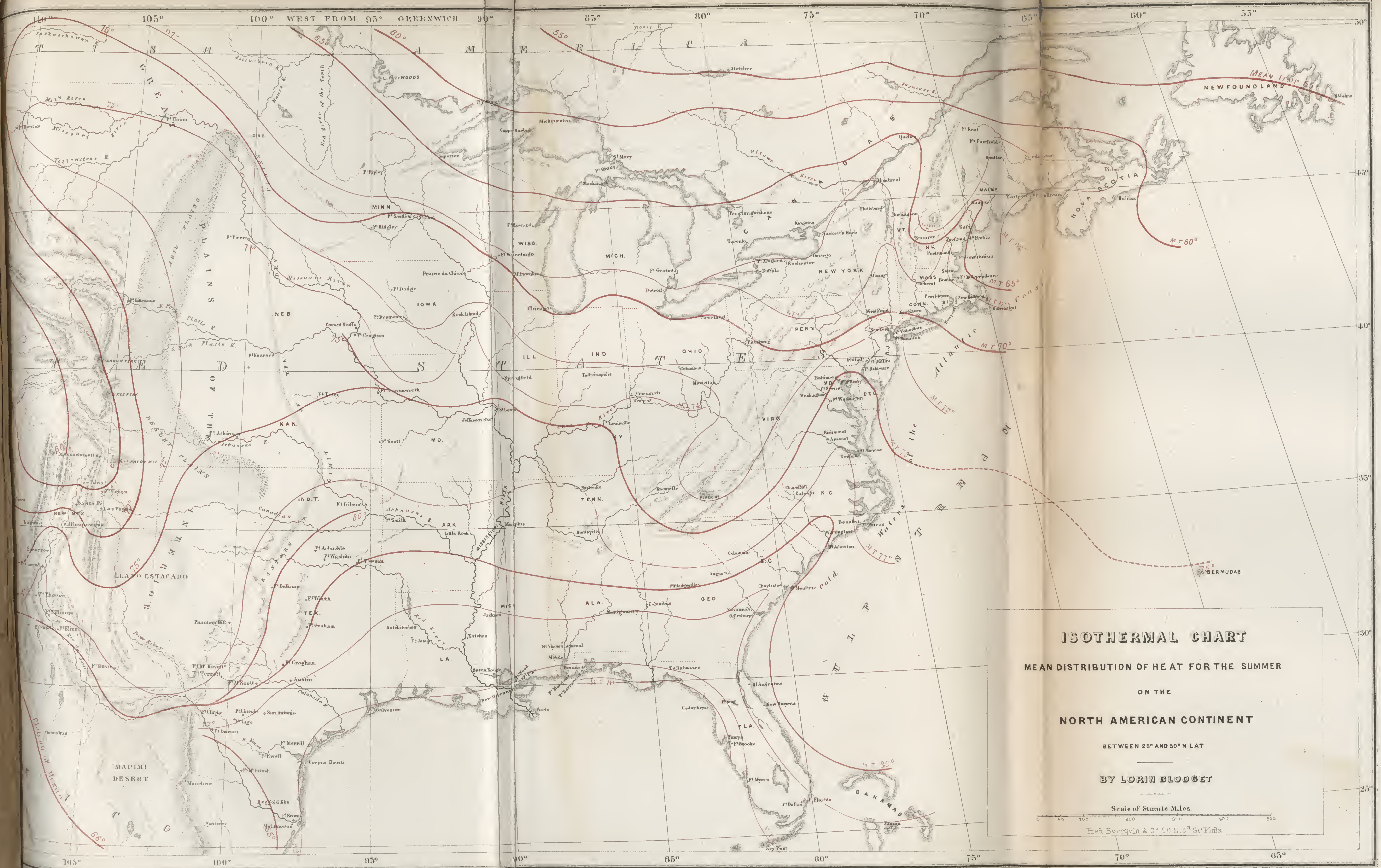
Ubajay is fifteen miles from Havana, and 242 feet above the sea: observations from 1796 to 1799. At Havana the dates were 1810 to 1812. *Humboldt's Personal Narratives, Climate of Cuba.*

The average temperature of the surface waters of the Gulf, as recorded in Maury's charts, is one authority for deduction of the air temperature. The following records confirm the assumed distribution: At Tortola, W. I., two years, 80.6 degrees; at Barbadoes, one year, 78.5 degrees, from Dove; at Caracas, one year, 74.4 degrees, from Kaemtz; at Vera Cruz, one year, 80.2 degrees, United States Army Meteorological Register, 1847. And generally the results at coast stations of the Gulf, as Cedar Keys, Fort Morgan, Camp Sabine, &c.

By many comparisons, Humboldt determines the mean temperature of the sea to be greater than that of the air above it, between the equator and 48° of north and south latitude. (Pers. Nar., vol. vii., p. 424.) This is doubtless more uniformly the case in the Atlantic than in the enclosed seas of the West Indies; and it is remarked by Humboldt, indeed, who gives as the mean annual temperature of the West Indian sea 79.6 degrees, with 82.3 degrees for the hottest season, (in February and March,) and 77 degrees for the coldest, which is in November and December. The summer of the north temperate zone would give little more than 80° for the water temperature, and it could not be placed above 80° for the air.—(*Ibid.*, p. 410.)



WEST FROM GREENWICH
GREAT BASIN OF THE INTERIOR
PLAINS
LLANO ESTACADO
MAPIMI DESERT
SONORA
Cold Waters of the Pacific Coast
Cold Waters of the Atlantic
MEAN SEA TEMPERATURES IN SUMMER
For areas of 5° lat. & long. each. W from S. Francisco
Lat. 40°
Lat. 30°
W Long.
San Francisco
WASHINGTON
OREGON
CALI.
UTAH
NEW MEX.
NEB.
KAN.
IND. T.
TEX.
DAC.
MINN.
IOWA
MO.
ARK.
LA.
WISC.
MICH.
ILL.
IND.
OHIO
KY.
TENN.
ALA.
GEO.
S.C.
N.C.
VIRG.
PENN.
NEW YORK
FLA.
BAHAMAS
EXPLANATION OF ISOTHERMALS
Lines of mean temp. differing five degrees
d° d° doubtful position
d° d° differing less than 5° from the next
Minimum or lowest position of an isothermal
Maximum or most Northern position of an isothermal


ISOTHERMAL CHART
MEAN DISTRIBUTION OF HEAT FOR THE SUMMER
ON THE
NORTH AMERICAN CONTINENT
BETWEEN 25° AND 50° N LAT.
BY LORIN BLODGET
Scale of Statute Miles
WEST FROM GREENWICH

mer mean temperature exceeds eighty-five degrees. In the upper valley of the Rio Grande they again appear, notwithstanding the increased altitude of three thousand five hundred feet, on the Mexican side at the Bolson de Mapimi, and in the valley at Presidio del Norte, as at several points in the more narrow valley on the north side of the Rio Grande below and at El Paso. The valley of the Colorado river of California is the district of greatest excess, however, the summer mean here reaching *ninety* degrees. A considerable portion of the desert bordering this river on the west doubtless is quite the same as the military position at Fort Yuma, though no other part has been observed. West of the Sierra Nevada another district of extra-tropical temperatures exists, in the San Joaquin valley, represented by Fort Miller, at which post the mean summer temperature for three years is 85°.5.

The lower valley of the Colorado has few parallels in temperate latitudes in its measure of mean temperature, if, indeed, a parallel in the same latitudes may anywhere be found.* But this and the other last-mentioned extreme districts are still more remarkable for the single extremes observed in these months, and in the mean temperature at the extreme hour of 3 P. M. At Ringgold Barracks, in the Rio Grande valley, the mean of the observations at 3 P. M. for the entire three summer months of 1850 is 101°.2, and the single extremes reach 107° for each month. Other stations in the same district give results so near to these that no considerable error of the instrument may be supposed to exist. In 1851 the measures for the same dates are but two or three degrees less in the means, and quite as great in the single readings at these posts, and in 1852 and 1853 they are very little different from, and on the whole as great as those of 1851. Still higher single readings are recorded in the Colorado and San Joaquin valleys of California, at Forts Yuma and Miller, the highest being 121° at Fort Miller, in July, 1853, and 116° at Fort Yuma, in June of the same year. The highest monthly mean for any hour is that at Fort

* In the collection of temperature tables by Dove some stations in India and Persia are given with very high temperatures, yet the periods are short, and some doubt rests on the adaptation of the hours to give the true mean. At Bagdad, Bassora, and Abusherehr, Persia, observations are recorded giving 92° and 93° for the mean of summer, but no mention is made of the hours of observation. At many points in India the months of May and June exhibit excessive heats, but the summer is usually a rainy season, and of a very large number of stations given by Dove but one, Pondicherry, exceeds 90° for the summer mean. This is at 11° 56′ north latitude, its summer mean for one year 93°.7. Ambala, near Delhi, latitude 30° 25′, has a mean of 100° for May and 96° for June ; Cawnpore, latitude 26° 30′, 95°.5 for May, &c. These are British observations, and their great number for India probably represents all districts where extreme temperatures exist.

Miller, for June, 1852, of 108°.4, at 3 P. M., with a single maximum reading of 116°. There are frequent instances of a mean temperature for a summer month exceeding one hundred degrees at 3 P. M., one of which occurred at Fort Gibson in August, 1834, and many within the five years of observation in Texas, New Mexico, and California.

The concurrence of so many records establishes the position that the summer temperatures of several districts in the temperate latitudes of this continent largely exceed those measures in its humid tropical climates, at least, if they are not quite unparalleled at any point.* As these appear at several points of districts generally similar, and in successive years at the same points, no considerable errors of the instruments may be apprehended, and none can exist which vitiate comparison with the records of other climates generally. The instruments were, indeed, all carefully constructed and carefully compared.

In this general view of the temperature distribution, there are one or two anomalous instances of refrigeration of the summer temperature which render the explanation of the facts of great interior heat more difficult than they would be otherwise. The greatest diminution of the summer heat is on the coast of the Pacific, and the contrast of that district with those in which the great extremes of heat have been recorded is most extraordinary. Fort Miller, in the San Joaquin valley of California, is less than one hundred and fifty miles due eastward from the coast of the Pacific at Monterey, where the mean summer temperature falls off to 57°. For the month of June, 1852, the mean of 108°.4 at 3 P. M., at Fort Miller, had a corresponding mean at Monterey of 63°.2, and a single maximum there of 70°—a difference in the means of forty-five, and in the extremes of forty-six degrees. The difference in the complete monthly means was thirty degrees.

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* In a table of maximum temperatures for the globe, Kaemtz and Martins give 117°.3 at Esnè, Egypt, as observed by Burckhardt, 113°.5 at Bassora, 112°.5 at Pondicherry, and 109°.6 at Philœ, Egypt. The highest at European cities are 101° at Catania, 103° at Palermo, 102° at Naples, and 101° at Rome and Paris. Humboldt gives as the maximum observed at Cumana, South America, "on days considered excessively hot," 90°.5, and as the highest in Havana in 1801, 90°.

An instance of desert temperatures in the Oasis of Mourzouk, Sahara, is referred to by Humboldt, where Captain Lyon experienced "for whole months the thermometer of Reaumur between 38° and 43°." (117°.5 to 128°.7 Fahrenheit).

At Vera Cruz the greatest heats do not exceed 95°. In the Red Sea the thermometer at noon is at 111°.2, at night 94°. At Benares, India, the heat in summer attains 111°.—(Humboldt's Pers. Nar., vol. vii.) In Dove's Isothermal Chart for July, a portion of the African Desert—Nubia and Arabia—is embraced by an isothermal of 90°.5. The mean of this month for three years at Fort Yuma is 92°.27, and for two successive years it exceeds 94°. It cannot be of less mean temperature, therefore, though but a point in comparison to the great Nubian and Arabian Desert, for the single month of July, or the mean of the three months of summer.

The measures of difference and contrast here given, are also in a great degree characteristic of large districts; as the cold of the coast of the Pacific in summer extends over twenty degrees of latitude, or from the fiftieth to the thirtieth parallel, while the extremes of summer heat are common to all the valleys and basins of the western portion of the continent, where a single range of mountains intervenes between them and the Pacific coast. The summer isothermal of 57° will be seen to extend along the coast from Sitka, in Russian America, to Monterey, giving an almost absolutely equal temperature for this extensive line of fifteen hundred miles of latitude, and near two thousand miles of coast. A portion of the coast of Oregon has temperatures noticeably higher, for the brief period of the record there, which may, perhaps, prove the position of the cold line to be a little distance off that coast at sea.

The Atlantic coast furnishes another instance of depression of temperature, from causes not common to all changes of seasons on the ocean coasts. The sea winds and mists are here noticeably colder than the average temperature of the sea itself, at any considerable distance, and exposures open to these have a temperature perceptibly reduced as far southward as Florida. As the positions of the isothermals of five degrees of difference are widely separated in summer, and as each therefore, approximately represents a large district, in which it may change position considerably for slight positive differences, the curvature for the lines, as drawn, gives a somewhat undue impression of these changes, and of the cooling effects of the coast positions. The lines, also, double on themselves abruptly to follow the warm atmosphere of the Gulf stream. The cause of this refrigeration is found in the cold masses of water present on the northern parts of the coast, or returning in currents next the Gulf stream, and beneath it. The existence of this current beneath is fully shown by the Coast Survey observations, and the fact, first noticed by Humboldt,* that deep lying masses of cold water may be pressed against shelving coasts by great ocean currents, and thus be brought to the surface, cooling the immediate coast more than any other point in its vicinity, appears to go far towards solving the problem of the presence of these cold waters, where no surface current is perceptible. For most parts of the Atlantic coast these causes are sufficient only to affect the winds from the northeast, which is the direction covering the largest water surface of this character, and the summer temperatures are reduced by the effect of these alternations, without the production of a decided single extreme, and without the uniformity which characterizes the refrige-

* Personal Narrative, vol. vii. p. 389.

rating winds of the Pacific. The phenomenon is sufficiently well known, yet it is not so decidedly associated as it should be with these cold, deep sea currents, and the masses of cool water off the coasts.* It is difficult to illustrate this feature by citation of measures of temperature, as the depressions appear in the form of two or three days of generally low temperature, without reaching a single minimum so low as might be attained at an interior station from the effect of radiation alone.

The Gulf Stream is somewhat above the mean temperatures of the east coast of the continent in the same latitudes, even in summer, and the isothermals would curve northward rather than southward in their extension at sea, if no influences other than that stream or the undisturbed sea were encountered. There is, however, no point of the coast at which the temperatures of summer are greater for the existence of the Gulf stream, as the continental influences everywhere predominate under the prevalence and controlling character of the westerly winds. The same atmospheric circulation carries the heated waters and their accompanying local atmosphere to the European coasts; yet there the temperature becomes reduced by diffusion over the sea, and the high proportion of moisture cools the summer climates rather than otherwise. This is shown by comparing the high temperatures of our dry western interior with those of western Europe.

The cold climates of the Pacific coast in summer constitute a general phenomenon of temperature distribution more difficult of explanation than any other, as the degree of refrigeration is so very great, and the contrast with interior districts so extreme over many degrees of latitude. The striking uniformity in the measures of mean temperature here, which has been alluded to as characterizing nearly all the observed points, is conclusive evidence of the existence of some general and powerful agency other than the immediate one of cold day winds. The analogies of the coasts of South America, Africa, and the north Atlantic would indicate at once a reference to great polar currents, and to the transfer of large masses of cold waters from the northern parts of the Pacific, but the ordinary sea observations have hitherto failed to discover any regular or marked currents here. Northward and westward from San Francisco the surface currents appear as frequently from one point as another on Maury's charts,

* Humboldt remarks (Ibid. p. 388,) that in July, 1804, the thermometer, off the Bank of Newfoundland, recorded but forty-seven to fifty-four degrees, while in the Gulf Stream it was at seventy degrees, and in the open sea beyond sixty-six and a half degrees; the air temperature on the banks, at noon, being fifty-eight to sixty degrees. He also notices the refrigeration of land climates near these masses necessarily resulting from their presence.

though the existence of a general movement from the northwest is recognized. There is, apparently, a deep-sea current from that direction of great magnitude and volume, which appears only by the lifting of its waters on approaching the coast, and in the general refrigeration of the waters of the whole area, with the consequent effect on the sea winds and on the climate of the land. The water temperatures noted in the summer months are less than those of winter, and their mean is nearly 57°, or that of the sea winds and of the summer on the coast. The body of water affected is shown by Maury's charts to extend northwestwardly toward the peninsula of Alaska, and to be strikingly uniform in its characteristics of low temperature, absence of surface-currents, and continuous northwest winds, so far as observed.* This great mass of cold waters, and its attendant cold surface atmosphere, develops a strong sea wind towards the gently heated and rarefied interior valleys and plains; and where these contrasts of temperature are greatest, the maximum effect is produced, as at San Francisco and Monterey. It is not strange, therefore, that the immediate coast is cooled to the temperature of the air and water of so large a portion of the ocean.

As the solution of this great depression of coast temperatures is evidently found in the temperature of the Pacific ocean, it may serve to confirm the accuracy of the observations there to give the mean of such observations as have been recorded at sea. Taking the observations in Maury's Wind and Current charts for these portions of the Pacific, in means for areas of five degrees of latitude and longitude, we find the areas westward of San Francisco to give 56°.5, 62°.3, 64°.4, and 68°, successively. The areas next southward, or between 30° and 35° of latitude, decrease in temperature westward from longitude 120°, by the successive numbers of 60°.5, 63°.3, 65°.7, and 66°.7, to the meridian of 140°. South of the parallel of 30° there are no summer observations on the coast. In the latitude of the Sandwich Islands (20° to 25°) the temperatures increase from 72°, at the meridian of 120°, to 77° at that of 150° in the vicinity of those islands.

* The temperatures of the cold currents of the Pacific coast of South America are very nearly the same as those observed here, even when intruded into the tropical seas of Peru. At Truxillo and Callao they were observed at 59°.5 and 60 by Humboldt, when the sea temperature beyond the current was 81°. Holmfeldt again observed the temperature of 60°.5, but there appears to be less parallel in regard to the differences of the seasons, and in the extreme effect on the climate of the land. It is remarked by Dove, also, in his essay on the isothermal lines, that the South American current is a deep mass, the soundings of the French exploration ship Venus giving a depth for it of 5480 feet. "It is a considerable section of the Polar Sea marching majestically from the south to the north." The analogy is very clear in the north Pacific.

The contrasts which induce these violent sea winds, exist only in the summer months, including May and September, as at other seasons the ocean is quite as warm and the land colder, and, whatever the degree of aridity, the sudden and extreme rarefactions do not occur in the interior. As this unusual circulation ceases the temperature rises, and the spring and autumn are both warmer than the summer, on the immediate coast, over a space embracing several degrees of latitude.

It may appear inexplicable that the northern districts of this coast, to fifty-seven degrees north latitude, should be equal, if not higher in temperature than that at San Francisco; but the refrigerating current appears to originate westward of Alaska, and to pass nearly due southeast from that point toward the continent in the latitude of Monterey; not entering the indentations of the Russian and British American coasts, probably, in any degree.* There may, also, be warm waters flowing over these from the central areas of the Pacific, from a division of the great warm currents of the Asiatic coast, and producing the general effect on the Pacific climates which the Gulf stream produces on those of Europe. Such is clearly the case in winter, when those movements outrank those from the Polar seas and give high temperatures for the whole mass of the Pacific, even where the cold waters are most marked in summer.

These comparisons are indispensable to show the reliability of the temperature measures given at Pacific stations, and that this anomalous arrangement of the isothermals is a correct representation. This arrangement is also independent of all considerations of altitude, as the construction of sea level isothermals for the interior would but increase the contrasts, and the coast stations are all at sea level.

In a more detailed explanation of the interior temperature distribution for the summer, a comparison of the successive districts may be made, commencing with those of the east.

In the New England States there are several points where the climates are principally maritime. Forts Sullivan, Independence, and

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* Richardson (Arctic Expedition, Climatology), in referring to the causes of high temperatures on the western coast of British America, says : "The course of the ocean currents, and the interposition of the peninsula of Alaska, and its prolongation in the Aleutian chain of islands, protect the west coast of America from the masses of drift ice which, in the same latitudes, encumber and chill the Labrador coast for most of the year."

In a paper presented to the American Association for the Advancement of Science in 1853, the writer examined the phenomena of unusual atmospheric movements in the lower latitudes of the United States as far as could then be done. The conclusions then outlined are fully supported by subsequent observation. (Proc. Amer. Assoc., 1853.)

Adams are particularly so, and we find at these a perceptible falling off from the high temperatures of other posts, especially in the maxima and in the range of summer temperature. Fort Sullivan has the same temperatures as the posts on the upper part of the St. John's river, at the extreme northern point of Maine, and two hundred miles from the coast. The altitude of this interior district is not very great, and the proximity of the St. Lawrence valley favors the development of the comparatively warm summer which is found along the line from the mouth of the St. John's river to Quebec. The interior rises so much southward that no line of warmer temperature appears until the plains near Montreal are reached, the vicinity of Lake Champlain in Vermont, the valley of the Connecticut river, and the southwest point of Maine, at Portland and Fort Preble. The line of 65° which passes here is sometimes found for several successive years in the valley of the St. John's, which has a general mean of 63°. The isothermal of 65° may also be extended in the low country of Maine as far as Bangor, returning along the coast nearly to Portsmouth, New Hampshire. Next a portion of southern Maine, New Hampshire, and Vermont, the valley of Lake Champlain, and the vicinity of Montreal may be correctly represented by the mean of 67°.5; and the general features, apart from the mean, are quite alike for these districts—all being interior climates, with a large range of single extremes, and of extremes in consecutive years. This measure is common to still more extensive districts, as it embraces nearly all of Massachusetts and of New York, with northern Pennsylvania, Michigan, and Wisconsin. The greater elevations of southern New England, New York, and northern Pennsylvania make up for the difference of latitude, and as the *general average of surface temperatures* is necessarily considered here, the districts enumerated may be quite identified. In all this area the deep river valleys, and particularly arid or sandy localities are excepted, and these may be assigned a mean temperature of 70° for the summer. Westward of the plains this very favorable measure of temperature only appears in the deepest valleys of mountainous districts, and under very different circumstances. It there, however, distinguishes the best portions of Oregon and California.

Between the mean of 70°, which appears in many localities of the last general district, and that of 75°, there is a very large area embraced, the extreme range east of the plains being from latitude 34° in northern Georgia, to Fort Snelling, latitude 45°. In the general phenomena of temperature distribution this district of the central States is quite uniform. Its single extremes of temperature are less than in the next cooler district, yet the range of the mean temperature is quite as great, or even greater. Thus the line of 75° varies its

position very greatly in extreme years, sometimes reaching nearly to Fort Howard, in Wisconsin, and again falling off to the northern line of Louisiana. On the Atlantic coast it ranges from New York city to central North Carolina, a range less than that in the Mississippi valley, but still greater than the range of the mean of 65°. This last has its greatest range on a line of contrasted altitudes from central Pennsylvania to Quebec, but in other positions and at equal altitudes its range is but about half that of the line of 75°.

There is great identity of the temperatures of this large area embraced by the isothermals of 70° and 75° east of the plains, including Iowa, Illinois, Indiana, Ohio, Kentucky, Upper Tennessee, Virginia, Maryland, Delaware, Pennsylvania, and New Jersey;—excepting from these some points of coast exposure and of the mountainous districts, the summer temperatures are more nearly uniform than those for almost any other continental area of like magnitude. The southern border of this district has fewer localities of very high temperature than are found in the next northern district, as the differences of local position cause much less difference in the mean temperatures. The lines curve only about the higher masses of the Alleghanies, and but for these they would have a very uniform direction a little north of west from the Atlantic coast to the Mississippi valley. The line of 75° is, however, as far north on the plains of New Jersey as at the Mississippi river.

The continuation of these lines over the plains and the Pacific districts is under peculiar circumstances, quite different from those prevailing at the east. Most of the area of the great plains is embraced by them, from the Llano Estacado of Texas to the most northern position on the Missouri river. West of 100° longitude the plains slope northward rather than otherwise, or the successive areas are more dry and desert-like on any meridian east of the Rocky mountains, as far as the south fork of the Plaste, which is more arid than points further south on the same line. So from the sources of the Canadian and the Raton mountains northward; and though at Fort Laramie and north of it there are elevations which interrupt the general slope, yet north of these again the plain of the Missouri river declines in altitude more than two thousand feet on a line due north from Fort Laramie. Fort Benton, at five degrees of longitude further west, and five and a half degrees of latitude further north than Fort Laramie, is 1850 feet lower. It is not surprising, therefore, that as the plains are in every part particularly liable to the accumulation of heat in summer, the mean temperature of the northern areas should be comparatively high, and should somewhat exceed that of the lake district and the Atlantic coast. The lines of 70° and 75° are, however, very remarkably sepa-

rated from that of 80°, and thrown much further north than might have been anticipated from the altitude of the plains, and from the climates of other parts of the continent. The observations for two years give a summer mean of 75° at Fort Pierre, on the Missouri, yet this isothermal returns southward again over twelve and a half degrees of latitude, to the upper plains of Texas.

Between the lines of 75° and 80° of mean summer temperature another large area occurs in the eastern part of the United States, and a large one also on the plains. It most resembles the district between the isothermals of 70° and 75°, and on the plains it is distinguished by a temperature very near to 80° over most of the district—the isothermal of 79° embracing the plains in the vicinity of the Arkansas for a large area.

The line of 80° is more uniform, and it embraces the whole lower States in a concentric curvature nearly surrounding the area of still higher temperatures from which a diminution is found in all directions—toward the Atlantic, the Gulf of Mexico, and the Mexican interior. The area so embraced is tropical in many of its features, and but for the winter extremes of low temperature it would rank fully as such. Except some portions near the southern extension of the Alleghanies and in western Texas, this measure of heat defines the cane district in its possible limits, and those in which it is now occasionally cultivated. The immediate Atlantic coast is colder, as was said in the general notices of temperature distribution for the summer, notwithstanding the near position of the Gulf stream, and the line therefore curves down the coast directly from Fort Johnston, N. C., to New Smyrna, Florida, returning up the western coast to Cedar Keys with but one degree more of heat. At Key West there are evidently local circumstances which augment the temperature beyond that of the channel between this point and Cuba—the sand surface of the island, small as it is, being probably sufficient to increase the temperature of the clear months one or two degrees. The record by officers of the customs for several years is slightly above the military record—the summer mean of those by W. A. Whitehead, esq., for six years previous to 1836 being 82°.3.

Within the Gulf the line of 80° scarcely appears, but the evidences are clear that the line of 81° may be continued in the direction of Vera Cruz. On the north the line of 80° again comes in at the foot of the principal plateau of western Texas, and embracing some portion of the dry plains near the Red river, it returns nearly to the recognized cane districts of Louisiana.

Within this is a district having a mean temperature of 82°, which includes a large share of Texas, much of Louisiana, and a small por-

tion of the plains from Mobile to Savannah. Only the southern and tropical portion of the peninsula of Florida attains this temperature, and at the interior posts of the neck of the peninsula between Fort Marion and Cedar Keys the measure of heat falls a little below 82°. The difference between this temperature and that of 80° does not appear to indicate much difference of general climate, and it belongs only to a surface facilitating local accumulation of heat, except in the vicinity of New Orleans and in South Florida, where tropical features are more fully developed in summer than elsewhere.

In southwestern Texas the extreme measure of 85° appears, which belongs to the exceptional climates of the western interior, and in this case is an accumulation from local radiation in a somewhat confined and sandy valley. But for the constant winds of the Rio Grande valley this accumulation would be even more extreme. When these winds change from their almost constant point of southeast, to true south, they bring a heated atmosphere like the desert winds of the eastern continent, and the conditions of exposure and locality are desert-like rather than tropical in this lower valley.

In explanation of the peculiarities appearing in the illustration of the great areas beyond the plains and to the Pacific, we may begin with the supposed extension of the isothermal line of 85° from the lower valley of the Rio Grande. The rivers entering the Rio Grande from the south are unimportant except in Chihuahua, and this plain, with the Bolson de Mapimi, a dry and heated basin 3800 feet above the sea, probably reproduces the high temperatures of the lower valley. At El Paso, which is more elevated and further north, the summer mean is at 82°. Beyond the mountains on the Gila and Colorado rivers there are also no mean temperatures observed, and the positions can only be defined approximately by reference to Fort Yuma and the Great Salt Lake. The mean of 85° must necessarily reach to thirty-seven and a half degrees north latitude there, and it reappears in the valley of San Joaquin at about the same point, as is shown by the record at Fort Miller. The line is bifurcated in that direction, and from the point of separation it extends down the coast within the first range of mountains and west of the Gulf of California. There are no records below San Diego, yet the known characteristics of the coast climate render it certain that neither this nor the isothermal of 80° reaches the Pacific shore at any point of the peninsula of California.

Within this line of 85°, at Fort Yuma, the highest mean temperature of 90° for the summer is attained. The exposure here favors the most extreme accumulation of heat, as sands and arid plains surround the post for great distances, and the principal winds bring only sand storms at this season. Little rain falls in summer, and the air is

distinguished by the intense aridity belonging to districts between the oscillations of tropical and temperate rains—the summer rains of Mexico approaching near this point on the south without reaching it, and the winter rainy season of the coast also near it, but never present. Its position is not wholly unlike that of the northern extremity of the Red Sea.

The isothermal of 80° is continued up the valley of the Rio Grande to Doña Ana, New Mexico, and it doubtless belongs to the desert portion called the *Jornada del Muerto*, below Fort Craig. Beyond this no records define it except at Salt Lake, where the summer mean is but little below 80°. Returning from the western part of the Great Basin, it is reproduced in the valleys of California at Sacramento, and from the southern point of the San Joaquin valley it crosses within the coast mountains, and remains east of these at least to the lower half of the peninsula of California. The temperature of most parts of the Great Basin can only be given approximately, but from the two positions of Salt Lake and Fort Yuma, and from the journals of survey parties which have traversed it, the summer temperatures are shown to be at least as great as those assigned in the position of these lines.

The line of 75° returns, as before remarked, a great distance from its most northern point on the plains to the Llano Estacado, and then recurves to Albuquerque, to return again two and a half degrees of latitude for the lofty plateaus of the Sierra Madre. It then surrounds the eastern and northern rim of the Great Basin, traverses the California valleys on a right line south, and is the highest isothermal appearing west of the coast range, near Los Angeles and San Luis Rey. It may be doubted whether a number of points sufficient to define the line here have been observed, as none but valleys of the warmest exposure go beyond 72°, on this western side of the mountains.

The plateau of the Rocky mountains increases in altitude southward from the Saskatchawan river so much as to cause the isothermals from 60° to 70° to run parallel to it from Fort Benton, on the Missouri, to Santa Fé, being as near each other at 47° 30′ of latitude as at 35°. The upper valleys of the Missouri and Columbia rivers are scarcely two thousand five hundred feet above the sea, and much of the great plain of the Columbia is elevated less than one thousand feet. The plains on both sides of the Rocky Mountains are open and dry, with little water or forest surface, and as they are also deficient in summer rains, their mean temperatures for this season are comparatively high. The isothermals of 70° and 65° are but little separated at these points, the first going to the 47th, and the last nearly to the 49th parallel. From the plains of the Columbia they run nearly south to San Diego;

the isothermal of 65° following the Willamette valley from Fort Vancouver, and that of 70° the valley of Fall river, east of the Cascade range, from Fort Dalles—both remaining within the coast range of California as far south as Monterey, from which point, though they are then inland as far as the western foot of this range, they go southward nearly to Los Angeles and San Diego.

The isothermals of 60° and 62° run nearly north and south on the Rocky mountain plateau to Fort Massachusetts, and on the Pacific coast they go below the 35th parallel. The valley of Frazer's river, north of Puget's Sound, extends the line of 63° some distance beyond the island of Vancouver, and the temperature of that island is probably quite as high, since Sitka has a summer mean of 57°, carrying the lowest isothermal of the chart to that remote point of the coast.

On the Rocky mountain plateau the observed mean at Fort Massachusetts is 61°, and that at Fort Defiance, much further south, 67°. The altitude of the first is 8400 feet nearly, and that of the upper valley of San Luis quite the same. The general altitude of the vicinity is much greater, and it may be assigned, at the Parks, at near 10,000 feet. At the South Pass the average of large areas would be about 8000 feet, but from this point the average altitude is less in proceeding north to the 49th parallel. The entire surface cannot be regarded as a plateau north of the 44th parallel, but it may be defined as such south of that line for all purposes of thermal illustration, notwithstanding the great altitudes and irregularities of its surface. In New Mexico, cultivated districts crown the principal ranges, as at Zuni, on the west, at 6500 feet; Las Vegas, Anton-Chico, and other districts on the east, at 6000 to 6800 feet; the Sangre de Christo and San Luis valleys at 8000 feet; Taos and Santa Fé at 8000 feet; and the Parks, which afford abundant pasturage, at 9000 to 10,000. For this purpose these districts must necessarily be regarded as plateaus, above which the sharp mountain ranges are lifted, and where the summer temperatures, particularly, to an extended area of surface, except for these particular peaks or ranges.

A brief comparison with the summer isothermals of the temperate latitudes of the eastern continent may here be given. The best illustration of that distribution is in Dove's isothermals for the month of July, and this single month does not differ so largely from the mean of the three months there as it would here.

The highest isothermal for July that touches Europe is the line of 77°, which crosses the southeast coast of Spain, the islands of Sardinia, Sicily, and Candia. A very large area east of the Plains, and most of the country south of thirty-seven and a half degrees of latitude, is warmer here, therefore, than any part of the continent of Europe.

The isothermal of 72°.5 embraces Spain, southern France, Italy, part of Austria, and Turkey. The difference of July from the summer mean would place the corresponding line of division nearly on the American isothermal of 70°, and a glance will show that all the area east of the Rocky mountains and south of Fort Snelling, the points of the Great Lakes and New York city, attains to this temperature. The line of 68° for July, runs a little north of east from Rochelle, France, nearly in a straight line through Germany and southern Russia; that of 63°.5 skirts the southern coast of England, and runs in the same direction from London through northern Germany and central Russia. Central Europe corresponds nearly to the American lake district, and the wheat climates of England and the Baltic find their parallel in summer temperature at the northern portion of Maine, Quebec, and Lake Superior. The lines of 59° and 54°.5 are more irregular in Europe, curving northward from the west of England to the White sea, and the lowest mean touching the north of Europe is 45°.5. Through Asia the lines of 65° and over run due eastward, but that of 63°.5 with all those at the northward diverge and spread fan-like over the great areas of northern Asia. On the east coast they all recurve southward quite abruptly, changing position more on leaving the coast than at the corresponding coast of the United States.

The temperate latitudes of northern Africa and the south of Asia present one or two points of comparison worthy of notice. The Gulf States and Lower California are in the latitude of the northern States of Africa, Egypt, Syria, and Persia, and the isothermal of 81°.5 for July which corresponds very nearly to that of 80° for the summer, very accurately defines this district of the eastern continent, except at the western coast of Africa. The line of 86° for July is traced at 25° north latitude in Africa, and 26° in Asia; differing little from the latitude of the equally heated valley of the lower Rio Grande, and being warmer than the same latitudes of Florida.

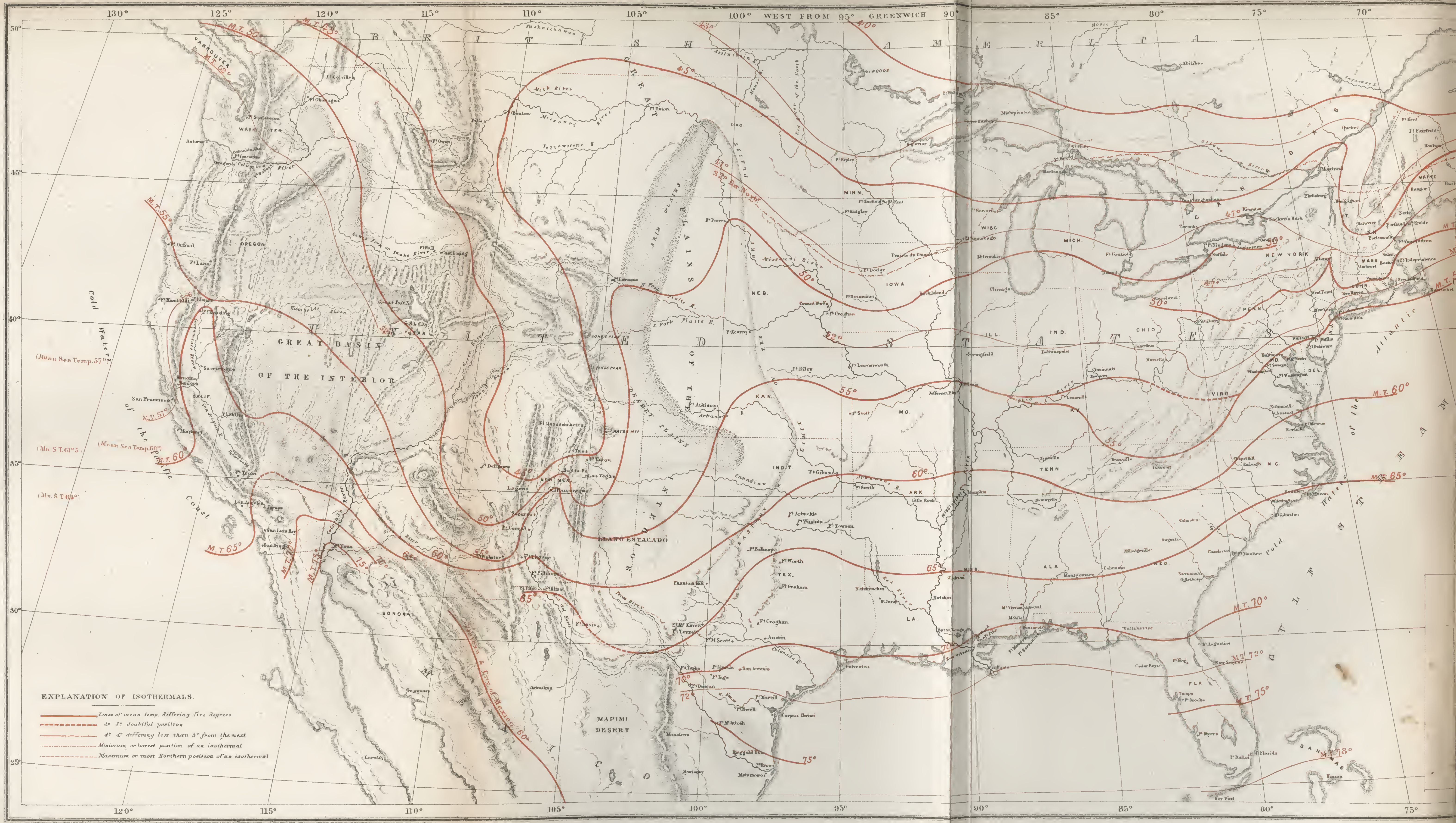
DISTRIBUTION OF TEMPERATURE FOR THE AUTUMN.

It has been mentioned in connection with the temperature distribution for the spring, that both that season and the autumn were scarcely capable of identification as distinct periods in regard to temperature, periods might be separated from other parts of the year, and compared for the various districts as definitely as the extreme seasons of winter and summer. In the most northern districts the autumn proper is shorter than elsewhere, and if defined by the period from the commencement of the decline of vegetation to its complete extinction it would be

scarcely so much as sixty days. All the area north of the 40th parallel and east of the Rocky mountains shares these abrupt transitions, and north of the forty-second parallel November belongs more correctly to the winter months. At the 45th parallel the average mean temperature of this month is about 32°, and its contrast with the temperature of September is very great. As the position of each month separately, and of the single limiting temperatures in regard to vegetation, is more important than that of the period of autumn as a whole, these features of the temperature distribution will be particularly referred to.

The chart embraces an isothermal of 32° for November, the only month in which that line cuts any district represented, and a thermal line may be drawn to define the mean position of single minimum temperatures of 36° to 40°, or of the first destructive frosts of each month, in addition to those representing the mean temperatures of the entire period of three months. The first of these lines, the mean of 32°, occurs only in November, and it cuts off a less area as belonging to the winter proper than the same line for the month of March in spring. The difference is greatest in the lake district and on the Atlantic coast, where the mass of surrounding waters retains its heat and modifies the temperature through a long period of continued low temperature inland, and where also the spring presents masses of ice retarding the summer advance of heat. Fort Brady and Fort Snelling illustrate these opposite results. At Fort Snelling each of the months named is near 31°.5, while March at Fort Brady is 6°.4 colder, and November 1° warmer than at the first post. The whole district influenced by the lakes, and all the Atlantic coast above Fort Monroe, exhibit the same results, the difference between the two months being five to seven degrees, while at all the interior posts they are nearly equal, and south and west of St. Louis March has the highest temperature by from one to three degrees. It is a noticeable feature of the entire temperature distribution that the decline in autumn occurs sooner at the southwest than elsewhere, and that the minimum is often in December, the spring returning as much earlier, and belonging to March more decidedly than to any other month.

The thermal line of 32° for November also shows that the temperature conditions for any entire line of latitude across the continent are more nearly equalized at that time than in any other case, as in the lake district and on the Atlantic coast this line bends northward to the 47th parallel, or even farther, and in its extension westward its position is but little north of this parallel. Between the Mississippi and Missouri rivers it curves furthest south, showing that the plains grow cold more abruptly than the districts eastward.



WEST FROM GREENWICH
BRITISH AMERICA
UNITED STATES
MEXICO
GREAT BASIN OF THE INTERIOR
GREAT PLAINS OF THE DESERT INTERIOR
LLANO ESTACADO
MAPIMI DESERT
SONORA
Cold Water of the Pacific Coast
Cold Waters of the Atlantic
GULF STREAM
(Mean Sea Temp. 57°)
(Mean Sea Temp. 60°)
(Mn. S. T. 61°5)
(Mn. S. T. 64°)
M. T. 50°
M. T. 55°
M. T. 57°
M. T. 60°
M. T. 65°
M. T. 70°
M. T. 72°
M. T. 75°
M. T. 78°
WASH. TER.
OREGON
CALIF.
UTAH
NEW MEX.
MINN.
IOWA
NEB.
KAN.
MO.
TEX.
IND. T.
ARK.
LA.
WISC.
MICH.
ILL.
IND.
OHIO
KY.
TENN.
ALA.
GEO.
FLA.
N. C.
VIRG.
PENN.
NEW YORK
MAINE
MASS.
CONN.
DEL.
MD.
San Francisco
Sacramento
Los Angeles
San Diego
Gt. Salt L.
S. L. City
Santa Fe
Albuquerque
Austin
San Antonio
Galveston
New Orleans
Memphis
Little Rock
St. Louis
Chicago
Milwaukie
Detroit
Cincinnati
Pittsburg
Buffalo
Toronto
Montreal
Quebec
Albany
Boston
New York
Philadelphia
Baltimore
Washington
Richmond
Norfolk
Charleston
Savannah
Mobile
Montgomery
Tallahassee
St. Augustine
Key West
Havana
Matamoros
Monterey
EXPLANATION OF ISOTHERMALS.
Lines of mean temp. differing five degrees
do. do. doubtful position
do. do. differing less than 5° from the next
Minimum or lowest position of an isothermal
Maximum or most Northern position of an isothermal

ISOTHERMAL CHART
MEAN DISTRIBUTION OF HEAT FOR THE AUTUMN
ON THE
NORTH AMERICAN CONTINENT
BETWEEN 25° AND 50° N LAT.
BY LORIN BLODGET
Scale of Statute Miles.
Fred. Bourquin & Co. 50 S. 3d St. Phila.
WEST FROM GREENWICH
NEWFOUNDLAND
NOVA SCOTIA
MAINE
NEW YORK
PENN
OHIO
IND.
ILL.
IOWA
MINN.
WISC.
MICH.
NEB.
KAN.
MO.
KY
TENN.
VIRG
N.C.
S.C.
GEO.
ALA.
MISS.
LA.
ARK.
TEX.
FLA
IND. T.
NEW MEX.
MAPIMI DESERT
LLANO ESTACADO
BERMUDAS
BAHAMAS
MEAN TEMP 40°
M.T. 45°
M.T. 47°
M.T. 55°
M.T. 60°
M.T. 65°
M.T. 70°
M.T. 72°
M.T. 75°
M.T. 78°

In October no post gives a mean temperature approaching this point; the lowest, at Forts Ripley, Wilkins, and Massachusetts, (New Mexico,) being forty-four and forty-three degrees. The measure of heat for this month declines as much from that of September, as that of November does from this, but the universally high temperature of September leaves a measure still quite high. The following table giving the decline of temperature in the successive months of autumn, may be advantageously compared with the monthly advance in spring, as given in previous tables. December is included, in order to embrace the entire period of declining temperature to the winter, and nearly to the yearly minimum at all points.

Stations.	Mean of Aug.	Aug. to Sept.	Sept. to Oct.	Oct. to Nov.	Nov. to Dec.
	°	°	°	°	°
Houlton, Me. . . .	64.5	9.3	11.9	12.5	12.7
Portsmouth, N. H. . .	65.1	6.1	9.5	10.7	10.1
West Point . . .	71.8	7.5	11.3	10.8	10.3
Toronto	66.3	8.2	12 9	8.6	10.4
Pittsburg	71.2	7.7	12.6	11.1	8.5
Norfolk	77.2	5.2	10.4	10.2	8.3
Tampa Bay, Fla. . .	80.4	1.1	5.3	7.1	5.0
New Orleans (Ft. Pike) .	82.9	3.8	8.6	7.7	7.0
Fort Gibson . . .	80 2	6.7	12.0	12.4	9.1
St. Louis	76.1	6.6	15.3	11.7	10.6
Detroit	67.4	7.4	12.4	9.4	11.4
Fort Mackinac . . .	64.0	9.0	9.9	12.8	11.2
Fort Snelling . . .	70.0	11.2	11.7	15.5	14.7
Council Bluffs . . .	75.4	10.2	13.6	15.6	15.8
Fort Kearney . . .	72.3	7.9	14.9	15.5	12.2
San Antonio, Tex. . .	83.9	4.2	7.6	10.3	10.9
Matamoras, (Fort Brown) .	83.8	3.2	6.2	5.3	6.5
El Paso, (Fort Fillmore) .	79.6	2.4	12.4	13.2	4.8
Santa Fe	70.0	8.1	10.7	12.7	8.3
San Diego . . .	73.6	2.8	5.3	8.6	5.2
San Francisco . . .	57.2	+1.0	0.3	3.6	3.1
San Joaquin, (Fort Miller)	83.0	7.0	8.5	12.0	7.4
Fort Vancouver . .	65.5	4.7	7.5	6.8	10.0

These results show that the diminution of heat for these months is more uniform than would have appeared probable when the diversity of the positive measures is considered. The decline to September is always least, that from November to December next, and the differences to October and November are much the largest quantities, and nearly equal. September is a summer month, except at the colder posts, and on the coast of California it is often the warmest of the year; at San Francisco one degree warmer than August. The area between the Rocky Mountains and the Mississippi grows cold most abruptly, both relatively and positively.

The temperatures of the Pacific coast are always anomalous, and

never more strikingly so than in these comparisons of points in the curve of successive months. September is seen to be warmer than August, and as this last month is warmer than July, the whole line from July to October is ascending, and November falls but little below the July mean. The same results are found at Monterey, and they appear to belong to the immediate coast line for several degrees of latitude. The mutual relations of the months are similar to those of tropical and equatorial districts, where the rainy season reduces the temperature of the months of summer, and the clear atmosphere of other months permits the highest temperatures of the year.

The general characteristics of the curve of temperatures through successive months for the various districts falls appropriately to the examination of the annual distribution of temperature and to the constants presented in another part of the work, and other references to the peculiarities of the curve of declining temperature will be made in that connection.

The lines marking the limit of mean single occurrence of frosts closing vegetation are most difficult to place, and they can only be regarded as approximations. The greatest distance southward to which cold extremes of a certain degree may fall in the most severe season is a point almost equally desirable, yet the non-periodic extremes are so variable in themselves, and they may become so great at remote intervals, that it is hardly possible to present a valuable result in regard to them. A temperature of 36° to 40° at sunrise is usually attended with frost destructive to vegetation, the position of the thermometer being usually such as to represent less than the actual refrigeration at the open surface. Taking the point of 40° as that which would give a frost in districts slightly more elevated and exposed than the posts themselves, as the adjacent country usually is, and the comparisons for the month of September through the last twelve years give the following results.

In 1843, 1844, and 1845, the posts of the south coast of New England, New York harbor, in the valley of Lake Ontario, and all south of Pennsylvania, gave no temperature so low as 40°, while those north of this line were at 32 to 39 degrees in the minimum for each year. St. Louis and Fort Leavenworth at the west were not below this limit of 40° except in 1844, when the temperature of 36° extended as far southward as Forts Towson and Jesup.

In 1846 there were no points in the observed districts of the United States where the thermometer fell to 40°, the month being unusually warm.

And in 1847 only the extreme positions northward, Forts Brady and Snelling, experienced temperatures below 40°.

In 1848 the extremes were very nearly as in the first years named. In 1849 the lake posts of New York, Carlisle Barracks and Fort Kearny, were at 40°, those northward being below, and southward above this point. In 1850 it was quite the same as in the previous year, and three posts of Oregon come in to give the exact measure of 40°, in addition to the posts enumerated for 1849.

In 1851 this extreme fell but little farther south—to Forts Scott, Leavenworth, and Independence, and it did not appear on the Pacific. In 1852 the stations of the Pacific and New Mexico gave temperatures below 40° as far south as Fort Reading in California, and at Fort Defiance and Santa Fé, in New Mexico. Fort Atkinson on the plains, St. Louis, West Point, and Boston, form a line from Santa Fé to the Atlantic, below which there were no observations so low as 40°.

In 1853 the low extremes for September were quite the same as in 1852. In 1854 they were observed only at the extreme northern posts in the eastern part of the United States; but in New Mexico and California there was but little change from the preceding year.

It will be seen that there is great uniformity in the position of a line representing the point to which at least one extreme of 36 to 40 degrees occurs in September, in successive years. If it were possible to divide the month it would give a more precise and valuable definition; but as it is, a line separating or detaching the coast of New England south of Boston, New York below West Point, the southern part of Pennsylvania, and extending through southern Ohio to St. Louis and Fort Leavenworth, would divide the districts of the eastern United States in which frosts might be expected in September, from those in which they would rarely or never occur in this month. In New Mexico all north of Santa Fé and Fort Defiance, and in Oregon, at all points remote from the coast, temperatures below 36° might be expected in this month for every year.

The most southern points at which this measure of single extremes may occur are at Baltimore, St. Louis, and Washington; and Forts Towson and Jesup, west of the Mississippi. The only instance of frosts at Fort Jesup in this period was in 1844, when two occurred at the close of the month, at recorded air temperatures of 36 and 39 degrees.* At the Pacific stations there is little variation in successive years, and liability to frosts is a marked feature of the climate of every part of the dry interior.

In October the extremes are such that in any considerable series of

* By the observations of Rev. Dr. Allan, of Huntsville, Alabama, for nine years, 1831 to 1839, the lowest point observed in September was 43°.—*American Almanac*, 1841.

years no portion of the continent north of the latitude of New Orleans escapes severe frost. In 1843 frosts and ice occurred everywhere except on the peninsula of Florida, though they were lighter on the Atlantic coast than westward. In 1844 they were equally general, though lighter near New Orleans, and occurring near the close of the month. In 1845 there were none south of Fort Towson and Norfolk, and they were light at both these posts. In 1846 and the two succeeding years the number of military posts was not so great as before, but for the first year the frost was apparently general in this month, and for 1847 and 1848 no considerable frost occurred in the Gulf States. The temperature of this month of 1849 was without any cold extreme for these States also, but in 1850 frost and ice occurred as generally as in 1843. In 1851 many parts of this district escaped frost, and in 1852 there was none below Forts Gibson and Washington. In 1853 frosts and ice were universal, except in the peninsula of Florida, and in a small portion of the lower valley of the Rio Grande; but in 1854 there were none in the principal districts bordering the Gulf. Thus in five years of a period of twelve the formation of ice occurred so generally as to destroy vegetation liable to be so cut off, before the close of October in the States bordering the Gulf, and it may be safe to assume that in the half of any period of years this will occur at all points north of the 30th parallel. The peninsula of Florida below 28° of latitude has no instance of frosts in this month, and the same exemption exists in the lower valley of the Rio Grande for the few years observed there.

In November some instances occur of absence of frost and ice along the borders of the Gulf through the entire month; 1844 affords one of these, but in the succeeding year severe frosts extend over most of the peninsula of Florida. The years 1846 and 1848 are similar to 1845, and 1847 is still more extremely cold. There are no exceptions to the liability in alternate years, at least, for any point except the south of Florida, from Fort Brooke to Key West, and at the mouths of the Rio Grande and the Colorado of California.

In all parts of New Mexico, when September does not bring ice and frost, they occur early in October, but in California the coast stations observe no ice until November, when it occurs at all points, and as decidedly at San Diego as at San Francisco. The following tabular arrangement of the date of the "first appearance of frost" at several posts of the Atlantic and Gulf States, New Mexico, and California, will compare this phenomenon advantageously:—

Stations.	1849.	1850.	1851.	1852.	1853.	1854.
Norfolk (Fort Monroe) .	Nov. 1	Nov. 18	Oct. 27	Nov. 14	Oct. 25	Oct. 16
Charleston (Fort Moultrie)	Dec. 13*	Oct. 26	Nov. 7	Nov. 15	Oct. 25	Nov. 14
St. Augustine (Fort Marion†)	Dec. 6	...	Dec. 5	Dec. 18	Dec. 30	Dec. 21
Fort Brooke . . .	None.	...	Dec. 5	Dec. 12	Dec. 12	Nov. 29
New Orleans . .	Nov. 9	Nov. 17	Nov. 25	Nov. 28	Oct. 31	...
Baton Rouge . .	Nov. 6	Oct. 28	Oct. 14	Oct. 16	Oct. 25	Nov. 13
Fort Kearney . .	Sept. 25	Oct. 5	Sept. 27	Sept. 26	Sept. 30	Oct. 4
Fort Laramie . .	Sept. 25	...	Oct. 5	Sept. 23	Sept. 30	Oct. 16
Fort Arbuckle . .	...	Oct. 18	Oct. 12	Oct. 9	Oct. 2	Oct. 20
Fort Brown . . .	Dec. 10	Dec. 5	Nov. 25	Dec. 22	Dec. 18	Dec. 6
Fort McIntosh . .	Nov. 25	Nov. 28	Nov. 21	Nov. 26	Nov. 10	Nov. 13
El Paso (Fort Fillmore)	...	...	Oct. 9	Oct. 9	Oct. 26	Oct. 29
Santa Fé . . .	Oct. 2	...	Oct. 1	Sept. 20	Sept. 14	Oct. 4
Fort Yuma . . .	...	...	...	Dec. 3	Dec. —	Dec. 26
San Diego . . .	Nov. 24	Nov. 6	Nov. 28	Nov. 6	...	Oct. 14
San Francisco . .	Nov. 6	Nov. 4	Nov. 28	Nov. 25	Nov. 4	Oct. 27
Fort Vancouver . .	...	Oct. 4	...	...	Oct. 22	Oct. 20
Steilacoom . . .	...	Oct. 5	Oct. 11	Sept. 22	Sept. 1	Sept. 19

None of the years embraced here is as cold as would be found in a period of ten years preceding, and the dates are generally later than the average of any series of ten years. The east and south of Florida, Fort Brown on the Rio Grande, and Fort Yuma, in California, quite uniformly are without ice and frost until December, though only the south of Florida, near Key West, appears exempt for all dates.

The limits just defined have been indicated on the thermal chart by lines for each of the autumn months. The curvature of the line for September, northward instead of southward, in ascending the eastern slope of the Rocky Mountains, is not less marked than in the lines representing mean temperatures, and the actual dates observed at Forts Kearny and Laramie, as here given, may be referred to in proof of the position given the line. West of Santa Fé, in New Mexico, the line would probably fall further south than it is now drawn, and embrace much of the mountain plateaus south of Fort Defiance, but there are no observations except at this post and Fort Webster, and at the last named there are no instances of ice occurring in September. In California the line follows the Sierra Nevada, and in Oregon it runs directly northward near the Cascade Range, the immediate coast being exempt throughout. The line marking this limit in October cuts off a narrow belt of the Atlantic coast below Charleston, the

* Frost on other parts of the island and on the main land earlier. For 1850, the date is that observed at Oglethorpe Barracks, Savannah, Georgia, and in 1851 there was no "killing frost" at Fort Moultrie until December 3.

† For 1849 the observation was at Pilatka, for 1853 at Fort Pierce, and for 1854 at Forts Capron and Myers. The dates correctly represent the east coast of Florida, below St. Augustine.

peninsula of Florida, and small portions of the coast of the Gulf westward. In Texas there is a large area so cut off, from the Colorado river to the Rio Grande, and in California a considerable district of the great Colorado, and all the coast below San Francisco. In November there are three small areas exempt from frost, the largest at the southern extremity of Florida, one at the Lower Rio Grande, and another at the mouth of the Colorado of California.

There are no sufficient data for comparison with similar latitudes in Europe in this important feature of temperature distribution. It is a distinguishing feature of the climate here, however, that these extremes occur in connection with very high mean temperatures, and that they belong to nearly every district, with very little apparent relation to mountains, whether near or distant. In the interior basins west of the Rocky mountains frosts are more frequent in comparatively warm months, yet scarcely a year occurs without the formation of ice in or very near to one of the summer months on the plains between the Ohio and Mississippi to the 40th parallel of latitude. These instances are, however, more remarkable as contrasts than important in practical results. In Europe the formation of ice in September is rare, if it occurs at all, at St. Petersburg; and the line of limit would probably extend to Moscow, and southeastward to Asiatic Russia at 50° of north latitude. The difference of latitude for western Europe from that of the central United States in this respect is more than fifteen degrees, therefore, and though the western coast here shows no instances of this phenomenon to the northern limit of the posts of observation, the distribution of these extremes is clearly to a lower latitude than on the eastern continent. At Pekin, China, in latitude 40° north, and corresponding in position with New York, the thermometer very rarely falls to the freezing point in October, and never in September, in the short period embraced by observations there.

The isothermals proper for the autumn chart show less abrupt curvatures generally than those for the spring, and if the deflections due to difference of altitude were removed most of the lines would nearly follow the parallels of latitude. The isothermals of 55 and 50 degrees are but slightly separated in New England, but in going westward they separate widely, and most on the Pacific coast; where that of 50 degrees does not cut the coast line at all, while that of 55 degrees falls nearly down to San Francisco. The lake district is warm in autumn, and the plains at the west of it retain so large a measure of heat that scarcely any depressions appear in the lines representing the mean, though November would give an abrupt depression at this point. To define the position of the lines for this extreme month, that of 32°

mean has been drawn on the chart, and its great southward curvature west of the Mississippi at Council Bluffs and Fort Des Moines, and its abrupt rise to Fort Brady, at the outlet of Lake Superior, show in a striking light the contrast of these districts in regard to the rate of temperature diminution as winter approaches.

The northern part of the area illustrated is warmer in autumn than in spring by about five degrees, the thermal line of 45° in autumn being nearly coincident with that of 40° in spring, but the distance separating the lines is not the same, and the correspondence is restored in going southward, the isothermal of 70° being in the same position in both. On the west coast there is little difference, except that the sea temperatures are higher in autumn, and the thermal lines curve northward instead of southward on reaching the Pacific. The large area between Fort Vancouver and San Francisco, which is at 52°.5 generally in spring, is again at the same measure, and this degree would probably correctly represent much of the interior area of half desert basins between Humboldt river and the Columbia.

On the great mountain plateaus the lines and curvatures are nearly as in spring, though warmer at the northern extremity. The thermal line of 45° might be carried across the Rocky mountains, at the 47th parallel, with but a small interruption, as these mountains form but a narrow range between the sources of the Missouri and of the north branch of the Columbia. The observations of the northern line of survey of the Pacific railroad furnish valuable data for the two points of Fort Benton and Fort Owen.

At the Atlantic coast there is less diversity in sea temperatures in autumn than in spring, and less contrast with those of the land. The sea, in the neighborhood of the Gulf stream, is warmer than the land, and the thermal lines generally curve slightly northward. At Bermuda the observed temperature for a single year is 71½°, which is warmer than the continent by nearly four degrees of latitude. A mean for a period of years would give less difference.

The Gulf of Mexico is warmer in autumn than in spring, though it varies very much from September to November. In the last month there is a greater refrigeration of the western than of the eastern portions, and the influence of the cold storms of that part of the Gulf and of the coasts of Texas and Mexico is very decided in depressing the mean temperature. As the air temperatures are deduced from those of the water, however, it is hardly possible to define the isothermals accurately, and they may require more decided northward curvatures over the Gulf than are here given them. South and east of Key West, in the vicinity of Cuba, the Gulf stream prevents the continental refrigeration from exerting the influence observed in other portions of

the Gulf, and the water temperature retains its measure of 80° throughout November.*

With the west coast of Europe the contrast is very great for this period, and the isothermal of 50° at Boston goes to 60° north latitude at the northward of Scotland, though it returns, through England and Germany, to the 47th parallel in central Europe. The warm waters of the Atlantic exert so marked an influence on the coasts and islands of northwestern Europe as almost to defy comparison with like latitudes anywhere. Within the immediate coast a contrast of less than five degrees of latitude exists in Europe as compared with the Atlantic coast here, and the immediate coast of the Pacific is quite similar to the European coast south of the British islands.

The oscillations of temperature in successive years for the same months, and for the mean of the three in autumn, is less than that occurring in the spring months having similar temperatures. It is also at a part of the year less important, in a practical sense, and less also in regard to the most abstract questions of temperature distribution. The illustration of this range by thermal lines for single months has not therefore been given. In the following table the points which were selected to represent the range in the spring months are given with the maximum range for the months of autumn, and the periods are, in most cases, or with the exception of the Pacific stations, sufficient to give the entire range.

Range of temperature in the mean of Autumn months.

Stations.	September.			October.			November.		
	Max †	Min †	Range.	Max.	Min.	Range.	Max.	Min.	Range.
Fort Snelling	69.1	54.2	14.9	54.7	40.9	13.8	42.8	20.5	22.3
Fort Leavenworth	73.7	61.3	12.4	62.5	46.6	15.9	50.3	28.6	21.7
Cincinnati	73.2	59.1	14.1	60.3	46.2	14.1	44.9	35.1	14.8
Jefferson Barracks	75.9	61.4	14.5	63.9	46.8	17.1	51.4	32.4	19.0
Fort Gibson	79.6	68.0	11.6	67.2	56.1	11.1	59.2	40.4	18.8
Fort Jesup	81.5	72.9	8.6	73.0	59.8	14.2	63.6	49.6	14.0
New Orleans	81.5	75.7	5.8	75.4	66.4	9.0	68.1	57.1	11.0
Fort Brooke	81.9	76.3	5.6	76.1	69.5	6.6	71.9	62.1	9.8
Key West	83.5	79.5	4.0	80.4	73.9	6.5	77.3	70.8	6.5
Charleston	81.5	72.9	8.6	74.2	63.2	11.0	64.5	52.0	12.5
Norfolk	76.6	68.5	8.1	67.2	56.9	10.3	56.1	44.3	12.5
Baltimore	71.6	61.8	9.8	60.1	48.2	11.9	53.5	38.9	14.6
New York	70.9	60.7	10.2	59.2	45.8	13.4	51.1	38.2	12.9
Pittsburg	69.9	57.4	12.5	58.0	38.2‡	19.8	45.3	30.8	14.5
Albany	68.3	56.3	12.0	53.3	42.3	11.0	46.7	34.2	12.5

* See Maury's Wind and Current Charts, Thermal sheet.

† The highest and lowest means of each series.

‡ For 1836. This was clearly the coldest month of this period, yet it is probably an error in some measure. The same month at Marietta, Ohio, was at 45°.

Stations.	SEPTEMBER. Max.	Min.	Range.	OCTOBER. Max.	Min.	Range.	NOVEMBER. Max.	Min.	Range.
	°	°	°	°	°	°	°	°	°
West Point . . .	69.1	60.6	8.5	59.0	46.0	13.0	49.9	36.4	13.5
Portsmouth, N. H.	62.2	55.4	6.8	51.7	44.5	7.2	46.0	33 9	12.1
Fort Sullivan, Me.	60.8	53.2	7.6	51.9	44.2	7.7	43.5	31.6	11.9
Ringgold Barracks	83.1	80.6	2.5	77.1	72.9	4.2	69.8	63.2	6.6
Fort McIntosh . .	86.6	80.7	5.9	77.2	71.2	6.0	68.0	60.2	7.8
San Diego	73.5	67.6	5.9	68.9	63.0	5.9	58.4	56.4	2.0*
Benicia	68.0	61.7	6.3	65.8	58.9	6.9	56.9	54.4	2.5
Fort Vancouver . .	61.6	60.2	1.4†	53.9	51.9	2.0	52.5	43.1	9.4
Fort Steilacoom . .	59.6	56.5	3.1	53.6	51.7	1.9	46.8	41.2	5.6

The general features of this variability are the same as in spring in regard to the preponderance of the quantities below the mean over those above it, and in the decrease of range toward the higher mean temperatures. November does not equal March in its measures of variation, however, the maximum variation for Fort Snelling being less by nearly fourteen degrees.

The range at posts near the Gulf of Mexico, and on the southern Atlantic coast, is surprisingly great for these months. At Forts Jesup, Moultrie, and Monroe, particularly, it seems scarcely credible that the same month should differ so largely in temperature in successive years. But the observations at other posts confirm these measures, and there can be no doubt of the reliability of results which agree at stations in the same vicinity both in their absolute and comparative temperatures. Whatever zero error may exist in any instrument, its comparisons for successive dates are not affected, and if the dates and measures of difference at two stations, not far distant, are found to agree, both records are sufficiently verified.

For the purpose of comparison of the measures of variation in a period of years in the interior of Europe, the following records may be cited:‡ Riga, on the Baltic, in latitude 56° 57′; Cracow, Poland, latitude 50° 4′; and Taganrog, near the Black sea in Southern Russia, latitude 47° 12′ north. At Riga, for thirty-five years, from 1795 to 1832 inclusive, the maximum range for the three months of autumn is 12°.1, 13°.1, and 20°.2, successively; at Cracow, for twenty-seven years, from 1826 to 1832, 11°.8, 10°.8, and 12°.4; and at Taganrog, for sixteen years, 1817 to 1832, 7°.2, 9°.4, and 20°.7. The range at London has been given in connection with the temperature distribution for the spring months.

* This month does not embrace a period sufficient to show the range at this station—it cannot be less than in the preceding months.

† Three years only.

‡ Annales de l'Observatoire Physique Central de Russie, St. Petersburg, 1853.

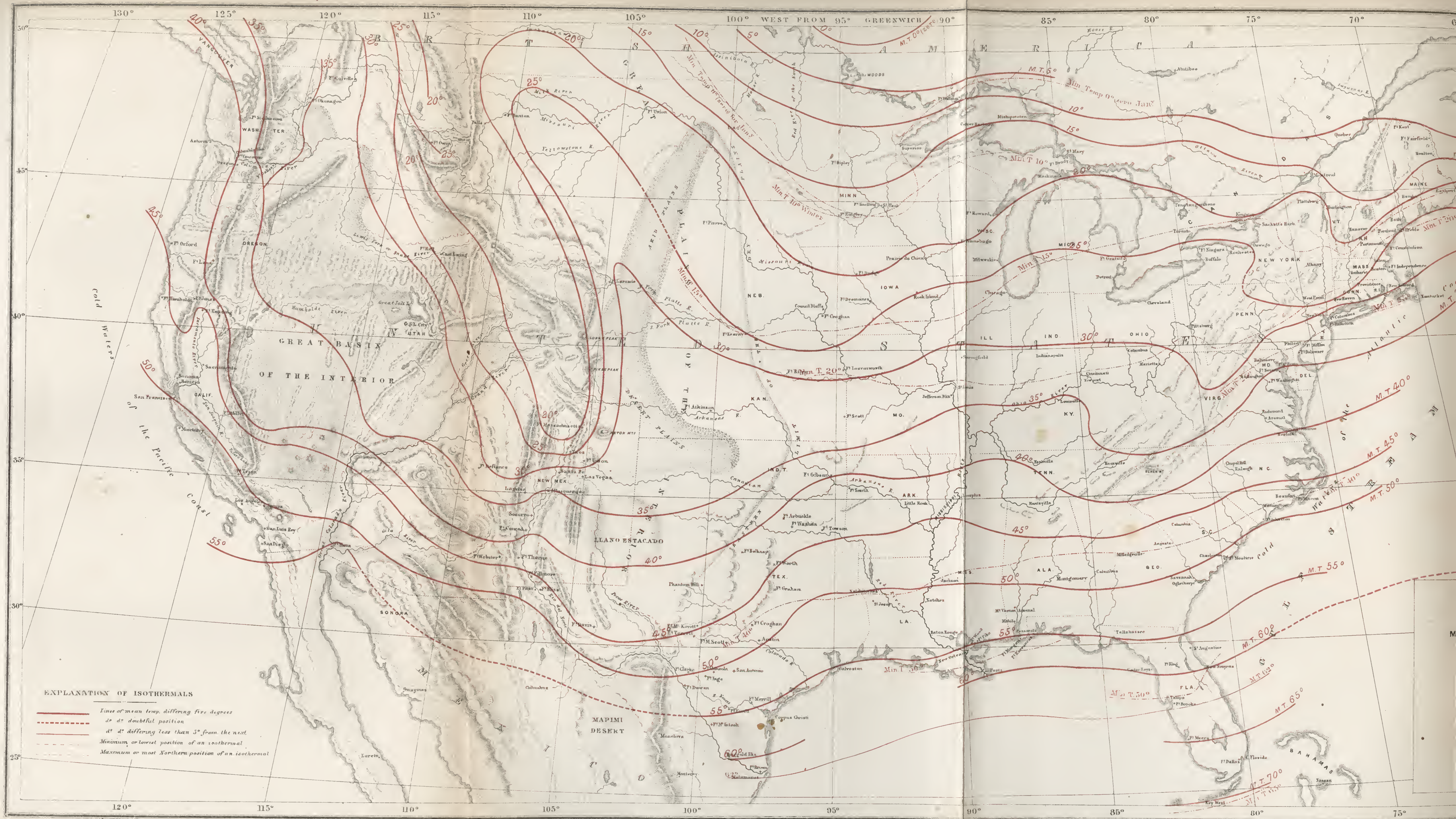
Stations.	September.			October.			November.		
	Highest.	Lowest.	Range.	Highest.	Lowest.	Range.	Highest.	Lowest.	Range.
	°	°	°	°	°	°	°	°	°
Riga . . .	57.8	45.7	12.1	46.1	33.1	13.0	40.5	20.3	20.2
Cracow . .	63.8	52.0	11.8	53.0	42.2	10.8	41.2	28.7	12.4
Taganrog .	62.6	55.4	7.2	53.1	43.7	9.4	46.8	26.1	20.7

These results show that the interior of Europe has a large measure of this description of variability, and that, if the corresponding portions of the two continents were compared, there would be less difference between them than is usually supposed to exist, if, indeed, any difference in regard to the variability of mean temperatures remained. It appears inexplicable that a difference greater than the measure of the lowest temperature above zero, may occur between like months of the successive years of a series at latitudes so low, and at stations with so high mean annual temperatures as Forts Leavenworth and Snelling, and this also without any apparent periodicity or gradation of years from the coldest to the warmest. These variations are undoubtedly absolutely non-periodic, since the longest series of observations show no return of any extreme, by whatever steps that extreme was at first approached, and the greatest contrasts are as likely to occur at dates very near each other as at remote points of the series.

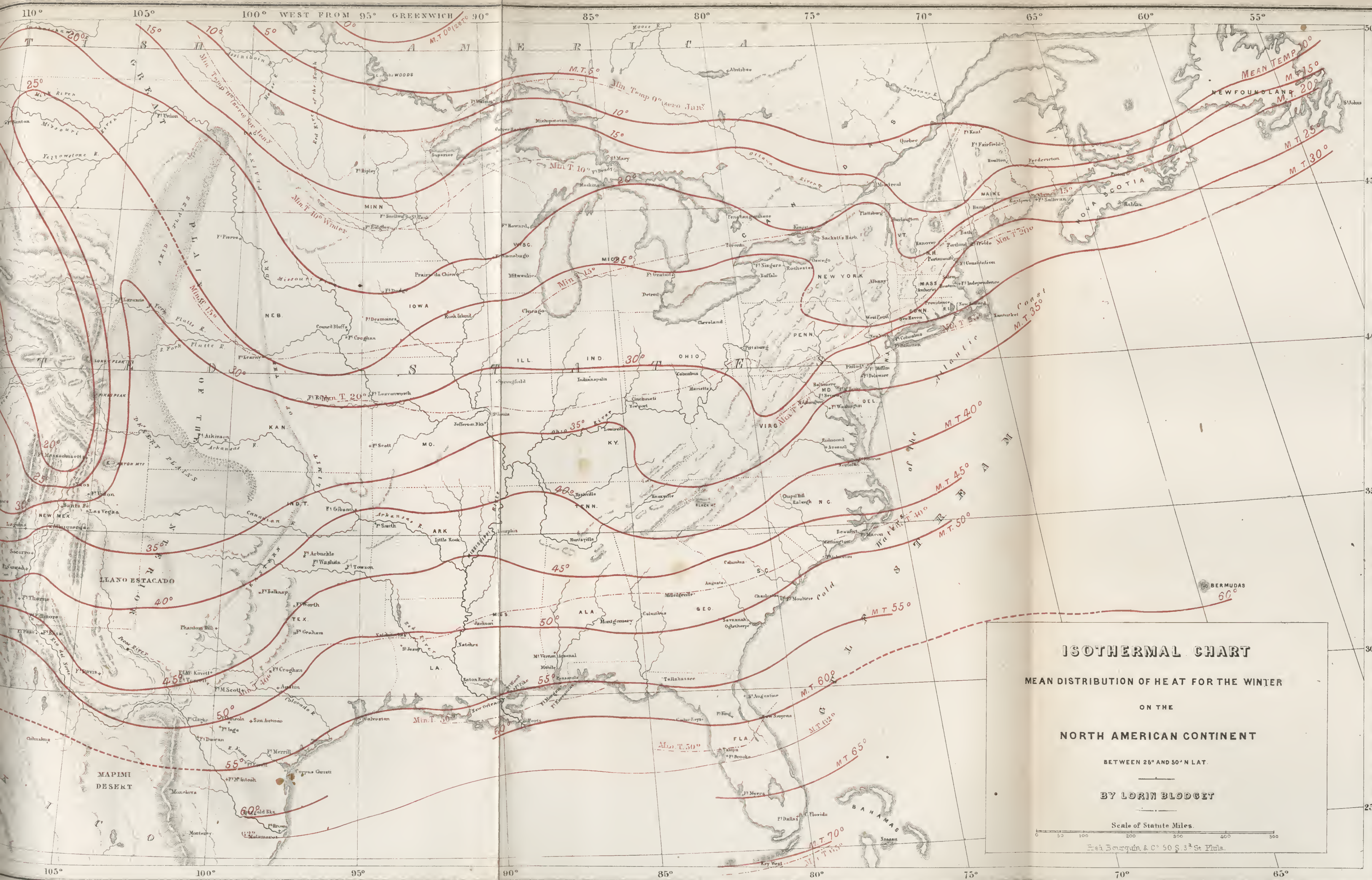
DISTRIBUTION OF TEMPERATURE FOR THE WINTER.

The order of arrangement of temperature statistics has usually been to place the results for the winter first, and in many systems to include the last month of each year with the first two of the next. This order makes the winter a continuous period, and its measurements of temperature, and other conditions, have heretofore been considered first in examining results for the year in most of the European systems. The inconvenience of this form of presenting the statistics has usually caused the arrangement of the results of observations in American systems in seasons derived from the single year, and the winter is thus made up of two periods, separated by the remaining months. In this arrangement the winter comes last in the enumeration, and has its more natural place in the thermal year, notwithstanding the defect of its period, since it is the natural close of the temperature curve rather than its beginning. If the consideration of time alone were not controlling, it would be still more appropriate to take the winter period of the three continuous months, as the last of the temperature divisions of the year.

There are many points of convenience, at least, in the order here followed, and the examination of the winter features is facilitated by



WEST FROM 95° GREENWICH
GREAT BASIN OF THE INTERIOR
LLANO ESTACADO
MAPIMI DESERT
Cold Waters of the Pacific Coast
Atlantic
EXPLANATION OF ISOTHERMALS
Lines of mean temp. differing five degrees
d° d° doubtful position
d° d° differing less than 5° from the next
Minimum, or lowest position of an isothermal
Maximum or most Northern position of an isothermal


ISOTHERMAL CHART
MEAN DISTRIBUTION OF HEAT FOR THE WINTER
ON THE
NORTH AMERICAN CONTINENT
BETWEEN 25° AND 50° N LAT.
BY LORIN BLODGET
Scale of Statute Miles.
0 50 100 200 300 400 500
Fred. Bourquin & Co. 50 S. 3d. St. Phila.
WEST FROM GREENWICH

passing immediately from its features to those of the year. The displacement of time for the first two months has no effect on a general summary, though single years are but imperfectly represented, and the comparison of months becomes the best mode of exhibiting the changes of successive years. The annual curve of temperature displaces the thermal year in its relation to the astronomical year by something more than a month, or from December 21st to January 28th for the average of the United States; and two-thirds of the period designated as winter thus belongs to the descending branch of the curve. As the characteristics of the three months are derived from the descending temperatures mainly, the more natural position of the season is at the last, and preceding the summary for the year.

The area embraced by these observations presents an extreme of low temperature, generally, for the winter; and the normal continental refrigeration, or that which would occur if no part of the continent had much elevation above the sea, is undoubtedly much exaggerated by the great altitude of the mountains and high plateaus near the Pacific. The western half of the continent is so much affected by this feature of configuration that no low inland areas experience a softened climate, like the climate of such areas in western Europe, and the question whether such sea influences exist here as are found on the west coasts of the eastern continent, has been much obscured for this reason, and it still remains imperfectly understood. It is very clear that the winter depression of temperature here differs more from that of the same latitudes in Europe than the measure of summer heat does from theirs, or, in a word, that if all the low temperatures here were less extreme, the parallelism of the two continents would be nearly restored.* The isothermals for the summer are, on the whole, in quite similar positions of latitude for the two continents, and the borders of the Gulf of Mexico, on the north, equal the temperatures of the south shores of the Mediterranean in the same latitudes. The line of 68° for July in Germany and central France is reproduced in Canada and on the plains of the upper Missouri on the same parallel; and this equality at that part of the year is very striking.

The causes of this extreme refrigeration in winter are probably simply continental, the vertical configuration coming in as accessory to some extent everywhere, and decidedly so at the Pacific coasts,

* Sir John Richardson remarks this feature of the comparison of the two continents in his analysis of the Climate of British America. (Arctic Expedition in search of Sir John Franklin.) "The mean annual heat of Europe is from 8° to 15° Fahrenheit greater than that of America at the same distance from the equator, while the summer heats differ only from 2° to 6°; the inferior mean heat of America is, therefore, due principally to excessive winter colds, and this is decidedly the case in the interior."

where the great altitude of the mountain districts near the Pacific very much aids to reduce the winter temperature by precipitating the moisture of the sea winds and surface atmosphere, and by preventing the circulation of the warm sea atmosphere to the interior. The high and uniform temperatures of the immediate coast of the Pacific to the northern limit of observations, is similar to the European condition, and the smaller distance to the refrigerated interior is due to the high mountains and sharp vertical configuration alone. The decrease in the winter mean is but ten degrees for fifteen degrees of latitude from San Diego to Astoria, or two thirds of a degree of temperature to one of latitude. Continuing to Sitka there is a diminution of six degrees of temperature for eleven of latitude, or nearly the same proportion. The influence of the Gulf stream on the coast of Europe is so great that the parallel conditions do not obtain, yet there is not a wide difference between the measures of diminution observed there and those of the Pacific coast.

Taking three stations on the western coast of Europe which most equally divide the distance to 60° north latitude, we find measures, both positive and relative, differing little from those of the Pacific coast of this continent, as may be seen by the following citations:

American Stations.						
San Diego,	Lat.	° ′ 32 42	Winter Temp.	° 52.3		
Astoria,	"	40 11	"	42.4	Dec. for 1° lat.	0°.74
Sitka,	"	57 00	"	36.5	"	0.55
European Stations.						
Lisbon,	"	38 42	"	52.5		
Penzance,	"	50 07	"	44.2	"	0.72
Bergen,	"	60 24	"	36.3	"	0.77

With this general feature of an equable temperature on the Pacific coast, and a wide separation of the isothermal lines, is next associated the rapid decrease of temperature on the meridians of the interior and the compression of the isothermals there, and at the eastern coast. Of isothermals differing five degrees but three can be made to cut the Pacific coast from San Diego to the 49th parallel, while in New Mexico six such lines are compressed within five degrees of latitude, and on a central meridian terminating at the mouth of the Rio Grande, thirteen isothermals of five degrees difference occur, and on the Atlantic coast the same number from Maine to Florida. The interior line crosses twenty-three degrees of latitude, and that of the Atlantic coast twenty-two, and taking the differences of temperature of the extreme isothermals we find the diminution to be at the rate of 2°.7 to one degree of latitude—a ratio, in comparison with that of the Pacific coast, of more than four to one. The compression of lines in

New Mexico is exceptional, because the altitude increases very rapidly, yet the area so influenced is so large that it is necessary to represent the superficial distribution without attempting to reduce the observations to their equivalents at sea level. The anomalous distribution which would be introduced by this course is elsewhere alluded to, and it is as necessary to adhere to the mode of illustration here chosen in winter as for other periods.

Notwithstanding the great interior altitudes, the general course of the winter isothermals very clearly recognizes the unequal temperatures of the opposite sides of the continent, which are usually considered to belong to the great land areas in these latitudes. The point of natural minimum temperatures for the continent is broken up by the presence of the great lakes, and for this reason the greatest depression falls west of them; though at several points further east, and in northern Maine particularly, the lines fall very nearly as low. With an allowance, even at a very low rate, for decrease of temperature with the altitude, the curve of the isothermals from the Mississippi westward would be quite sharp toward the north, and the analogies of the winter distribution on the eastern continent would be found to hold. But for the local influence of the great lakes this curvature would evidently find its lowest point farther east, and the coldest district would fall, as in Asia, near the eastern border of the continent.

The ameliorating influence of the lakes is too decidedly marked to escape attention, and its favorable effect on the general climate cannot be unimportant. The peninsula of Michigan, Ohio, New York, and Vermont, with much of Canada, show decidedly high temperatures near the lakes, and the abrupt curve of the isothermals from the Mississippi valley to Lake Michigan proves that the altitude is not the cause of the amelioration. The presence of these large bodies of water in the area when the greatest winter cold would naturally fall, is most fortunate for the cultivable districts of this part of the United States, and though they may, from some addition to the humidity, add something to the sensible temperature of the colder months, they prevent the extreme low temperatures which would otherwise occur.

The east side of the continent agrees strikingly in temperature with similar latitudes of the east of Asia: Pekin at 40° of latitude has a winter mean of 30°, or very nearly that of New York. The general position of the isothermals for January given by Dove for the two coasts is quite similar, and the Asiatic coast has also a warm ocean current similar to the Gulf stream. The greater contrasts of the two continents thus belong to the western areas, or to the comparison of this, as a whole, with the unusually warm area of western Europe.

The position of the thermal lines in the northeast, on leaving the coast towards the interior, should have a sharper curve southward than that given them from the posts of northern Maine, as these posts are much less elevated above the sea than the interior of New England generally. The lake valleys are all low also, and the isothermal of 25° recurves from Fort Ontario to the highlands of southern New York, and falls off southward some distance before finding a passage across the high interior of these States. The line of 32° has less curvature at its passage of the mountains, and its general course from the coast to the interior is slightly south of west—at its lowest point on the plains being near three degrees south of its position near New York, on the Atlantic coast.

Below this line the isothermals are but little curved, and they all tend southwestwardly, though, with corrections for altitude, they would recurve northward beyond the Mississippi, except at the Lower Rio Grande. At this last point it is clearly colder in winter than at the sea level in any corresponding part of Florida. The peninsula of Florida has two thermal lines which do not appear in Texas, those of 65° and 70°, and the highest temperature of Texas, 62°.5, cuts the Florida peninsula at the middle, and at a point two and a half degrees of latitude further north than its position in Texas.

The central portion of the plains at about the 97th meridian is the line of minimum temperatures, and of the most extreme southward curvatures. West of this they divide in both directions, going much further south on the high plains of Texas, and bending still more sharply north on the northern part of the great plains. The line of 32° is the first which curves north instead of south as the altitudes increase —that of 30° changes position still more, and that of 25° passes from a point south of Fort Kearny on a diagonal to the areas of latitude and longitude to the sources of the Missouri river, or across eight degrees of latitude. This is an unexpected result, which is due in part to the decrease of altitude on this line from the Arkansas to the Upper Missouri of more than fifteen hundred feet at 105° west longitude, and of two thousand feet from Fort Laramie.

On the plateaus of the Rocky mountains, and in New Mexico, the curvatures are generally similar for all seasons. The great return curves are mainly due to altitude, and they bring the winter climate of Fort Mackinac down to the 37th parallel in New Mexico—a mean of 20° being found there, at Fort Massachusetts, while the mean of 40° occurs at Fort Monroe on the same parallel of the Atlantic coast. The line of 32° lies south of Santa Fé, and west of the Rio Grande the plateaus of the Sierra Madre, at Fort Defiance, are two or three degrees colder still.

From this last point the thermal lines of 20°, 25°, and 30°, run on true diagonal lines northwest, and those of 32° and 35° nearly so, making only a single curvature southwestward in the mountains of Oregon; but neither of these lines reaches the coast at any point south of Sitka, in latitude 57°. The line of 40° is pressed westward by the mountains so much as to run parallel to the coast from the northern line of the chart to California, and here it turns to the Sierra Nevada, which is followed most of its length. The position of this line with those of 45° and 50°, is undetermined between the posts of California and those of New Mexico, but they are connected in the view that the deserts which they cross are here elevated and cold in winter, and that the districts east of the Colorado are still more decidedly cold at this season, as they are known to be very greatly elevated in the vicinity of the thirty-fifth parallel. The lower valley of the Colorado, at Fort Yuma, gives a high winter temperature, compared with the districts in its vicinity, yet it is much less extreme in this comparison than at other seasons. On the coast, as has before been noticed, the lines have a sharp curve northward, and they are widely separated, those of 45°, 50°, and 55° only, appearing on its whole extent.

At sea, on the Pacific side, the absolute temperatures are at once higher than those of the land, and higher than in summer for two or three degrees of longitude next the coast. The thermal lines bend abruptly to conform to this difference, but it is probable that after changing position four or five degrees of latitude, they follow the parallels for an indefinite distance toward the central regions of the Pacific ocean. The mean of a sufficient number of observations to afford a near approximation to the water temperatures here, gives the numbers 56, 59, 57, 57, and 58,* for successive areas of five degrees extent, both in latitude and longitude, from San Francisco to the meridian of the Sandwich Islands. On the next line, of similar areas southward, or between 30° and 35° north latitude, the numbers in succession from the coast are 56.5, 57, 63, 64, and 57. The number of observations in this case is less than before, and the irregularity of these numbers is due to their incompleteness.

In the Gulf of Mexico the water temperatures are much above those of either coast. The mean of three sets of observations, equidistant in the area from New Orleans to the 25th parallel, gives 70° for the body of water nearest the coast, 73° for the second, 76° for the vicinity of the 25th parallel. Yet the temperature at Fort Brown, near the mouth of the Rio Grande, is but 62°.3, and Key West, at this parallel, and surrounded by warm waters, has a winter mean of

* From Maury's Charts.

but 70°. There is, undoubtedly, a difference as great between the temperature of the air of the Gulf in winter and that of the waters, as between the measure at Key West and that derived from the mean of water temperatures at this parallel. The known preponderance of land winds, and the frequent occurrence of great depressions of temperature during these winds, may account for a greater difference between sea and air temperatures, under these circumstances, than would be found elsewhere. Sudden and extreme changes, reducing the temperature of the air many degrees for two or three days, are characteristic of the winter climates all around the Gulf, and as the surface waters continually come from warmer climates to supply the draught of the Gulf stream, the water participates less in these depressions than the air, or than bodies of water not constantly supplied with new accessions.

The Gulf coasts are not modified by its high temperature in winter so much as would seem inevitable under ordinary circumstances, and the only apparent reason is the great relative refrigeration of the continent generally, and the consequent prevalence of land winds instead of winds toward the continent. These winds are violent, also, in proportion to the contrast of temperatures, and as no general atmospheric circulation aids to drive the sea air inland, as is the case in the west winds of the European coast, and to some extent in the summer winds of the Gulf, the natural reversion from the land prevails, and little modification of the winter climate of the coasts is due to the presence of warm waters in the Gulf.

Similar results belong to most of the Atlantic coast, and the thermal lines at a distance from the land all curve largely northward under the influence of the warm waters of the Gulf stream. Observations of water temperature very near the coast give measures but little higher than those observed at posts on the land; but at short distances at sea the increase of temperature is very great, and if the prevalent winds were reversed, the climate would be greatly softened by the proximity of waters of so high a temperature. Off the coast at Norfolk, the first set of observations for the winter months, from a breadth of one degree of longitude, gives a mean for the water of 46°, the next 61°, and 65°, 69°, 68°, and 67°, successively; showing a rapid increase, and a very high temperature for the central bands of the Gulf stream, beyond which they fall off somewhat.* These temperatures

* The observations here used are from Maury's charts. The Coast Survey researches (Coast Survey Reports for 1853 and 1854), give decisive measurements of deep-sea temperatures in the Gulf stream, and of the position of the various currents and bands of warm and cold water.

greatly modify the heat of the air at the locality, and they require the compression of the isothermals quite closely along the northeastern coast and near Newfoundland. As the sea has a temperature of nearly 50° at the 40th parallel, and within the principal part of the Gulf stream—the mean of sixty-five observations off the coast between 37½° and 40° of latitude, and west of 70° of longitude being 51°—the isothermal of 50° must come near this latitude on the meridian of Newfoundland, and the lines from 25° to 50° are, therefore, compressed into a space of seven degrees of latitude in winter on the Newfoundland banks. At high temperatures the measure for the air may differ largely from that for the water, especially where strong atmospheric movements from land areas change the temperature rapidly, but at temperatures near 32° the difference is much less, and over unfrozen seas the air is usually retained at or near that temperature, when great comparative depressions occur on the land.

In constructing the isothermals of the northern boundary for the winter, the most thorough comparison of accessible data beyond the limits of the United States has been made to ascertain whether the positions given by the military posts there would be essentially modified in any case. At this season the changes for like distances of latitude are greater than at any other, and the minimum of continental temperatures is well defined, falling to nearly zero of Fahrenheit at the 95th meridian.

The British American observations, with others at the northern limits of the United States, show a diminished range of non-periodic variations of temperature in winter as compared with lower latitudes, which may be found to belong to the lake district and the north Atlantic coast, however, rather than to northern latitudes simply. The following comparisons illustrate this important fact in temperature distribution:

Northern posts of the United States—				
Hancock Barracks, Me.	17 years,	maximum	winter range	7°.1
Fort Brady, Mich.	31	"	"	7.2
Fort Mackinac, Mich.	24	"	"	9.9
Western posts—				
Fort Winnebago, Wis.	16	"	"	9.4
Fort Snelling, Min.	35	"	"	15.9
Southern posts—				
Fort Gibson, Ark.	27	"	"	14.4
Fort Jesup, La.	23	"	"	14.8
Fort Moultrie, S. C.	28	"	"	16.7
St. Augustine, Fla.	20	"	"	15.4

The posts of the western interior are seen to be exceptional, and to have nearly as great a range as those at the south, yet it is clear that

low temperature alone, beyond a certain limit, has the effect to diminish the range of non-periodic oscillations, and to render the climate more equable. If this outlined result shall be found to be sustained, it would point to the conclusion that the great non-periodic variations of temperature are confined to the temperate latitudes mainly, or are only intruded into the arctic regions in the summer and in connection with a certain degree of heat and certain conditions characteristic of temperate climates.* The most striking range is shown at Charleston (Fort Moultrie), and, in the absence of supporting observations, its accuracy might be doubted, but the extreme dates, which are 1828 for the high temperatures, and 1831 for the cold extreme, are also the dates compared at St. Augustine, Florida, with nearly the same range. At Augusta arsenal, Georgia, the same dates give a range of 14°.3, and at Fort Johnston, N. C., a range of 16°.7, or precisely the same as that observed at Fort Moultrie.

On the Pacific coast the periods are insufficient to show what the range for the winter may be, but the greatest recorded in periods of six years is four degrees. It is undoubtedly less than that for any other districts, as, at Key West, years next succeeding each other frequently give a greater range, and the greatest in fourteen years is 8.2 degrees. The stations in New Mexico are also incomplete in their

* The Arctic temperatures hitherto published are scarcely decisive of this point, yet the uniformity of winter temperatures in very cold climates is constantly noticed. Richardson remarks that "in the high latitudes the mean heat of the three winter months does not vary greatly in different years," and that "the intense winter colds are due, in a great measure, to active and undisturbed radiation." He also infers a small range of summer temperatures in high latitudes; but there are frequent references, both in Richardson's work and in others of a like character, to seasons "a month later" or a month earlier than usual, and to great differences in the amount of ice and snow at like dates of the warm seasons in these latitudes.

Since the above was written, Richardson's volume of Observations at Lake Athabasca, &c., has been published, and it contains some evidences of great variation of winter temperatures. At Lake Athabasca, in January, 1844, the cold was extreme, the month differing from the mean of December previous by 23° (mean of Dec. 1843, 0°.4; of Jan. 1844—22°.7). At Toronto the two months differed 10°.1 only. At Fort Snelling they differed 13°.7. Richardson also remarks a sudden change of temperature from 3 p. m. of March 22d to sunrise on the 25th of 64°.9, the observed temperatures being 42° and —22°.9 respectively. (p. 136.) The range of monthly extremes at Lake Athabasca and at Toronto is compared for several months, showing that at Athabasca to be much the greatest.

		Highest.	Lowest.	Range.		Highest.	Lowest.	Range.
		°	°	°		°	°	°
November, 1843 . .	Toronto,	51.6	15.4	36.2	Athabasca,	32.7	—9.4	42.1
December, " . .	"	41.4	4.2	37 2	"	35.3	—35.2	70.5
January, 1844 . .	"	45.0	—6.0	51.0	"	14.6	—47.7	62.3
February, " . .	"	47.6	1.2	46.4	"	37.5	—32.1	69.6
April, " . .	"	75.0	21.1	53.9	"	68.0	—3.3	71.3
May, " . .	"	78.0	29.3	48 7	"	72.5	12.6	59.9

periods; but the range appears to be very nearly the same as at the same temperatures in the eastern United States.

The range for single months of the winter has less practical importance than that for the seasons previously noticed, except, perhaps, at the extreme south, where a semi-tropical cultivation exists. This range is everywhere very great, and the minimum in any winter very irregular in its position in the period of three months. There is, also, the most absolutely non-periodic character belonging to all these changes, both as regards the same year and in a series of years. As an instance, the mean for January at New York is fifteen times below 30° in a period of thirty-three years, yet there is no similarity in the relations of any single date or succession of dates, and no approach to symmetry of the curves of a line traced through the successive means. In a line so traced for January there are five instances of large departures, with one or two years intervening between the extremes; but there are also many single departures or differences, nearly equal to those, made up of two or three years, and there is no apparent conformity of any portion of the line with a striking feature of any other portion. In February there are three or four high and low points, but they are unequal in degree and in distance. In December the same great and unequal variations occur, with a preponderance of large changes in single years, as in February; and the only noticeable feature of uniformity is that the opposite extreme for any month may be expected in the first year, or within two or three years, following a very warm or very cold month.

The period of a month is generally taken as the average duration of the greater number of non-periodic variations, and these comparisons confirm the correctness of this definition of the period of a large class at least, as the number of contrasts is equal to the number of coincidences in comparing the three months. Taking the coincidences, or the curve for the whole winter, into consideration, we find the same irregularity of position, and the same preponderance of large changes in a single year. If there is a periodicity in either period, no trace of it is apparent in the curves for this period of thirty-three years.

The discussion of other series is perhaps unnecessary in this connection, as it is apparent at a glance that their general features are the same. The field opened for tracing the position and degree of these non-periodic variations is, however, an unequalled one in respect to the area they influence, if not sufficient in regard to time to decide the question of periodicity beyond question. As the signal monthly extremes belong more decidedly than otherwise to the colder months, some comparison of the districts influenced by these variations may be made here.

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In an analysis of the cold extremes in detail for the winter, we find five instances, in thirty-five years, of a mean below 6° for January at Fort Snelling. The lowest, in 1820, appears to have been general, but it cannot be traced, as there were then few perfect records; the next below 6° was in 1834, and belonged only to January; in the lake district and at the east there was but little change, and the depression was not thrown forward into the next month; but all the western interior had a temperature 8° to 12° below the average, even as far south as Fort Jesup. At New Orleans the fall was less, and Key West was about 5° above the mean. This refrigeration was evidently confined to the interior, and had no progressive movement, as the following month was of a higher temperature than usual everywhere. The next of this class was in 1847, and the cold characterized the whole winter, with much the lowest point in January. Going east, as before, from Fort Snelling, the cold of the whole period disappears in New York and the northeast; but the upper lakes show a considerable depression, which extends, as before, only toward the south and west, and disappears before reaching Florida. At these posts, again, the heat is much above the mean, and this is the case as far north as Fort Monroe. The next instance is in 1849, when January is the coldest point of a cold winter at Fort Snelling, as in the previous cases; it is similarly cold at all the northern posts to the Atlantic, and as far south as New York; but there is little change at Detroit and in the interior southward; the south Atlantic posts are at the average temperature, and those of Florida warmer than usual in January, though 2° or 3° colder in February. At New Orleans this last feature was still more decided, but the western interior gave, as in the previous case, the same low temperature that was felt at Fort Snelling. In 1854 the lowest point since 1820 was observed at this post in January, and the relations of this may be widely traced at the west; but at the east it was not felt at all, and in Florida a reverse condition prevailed to some extent,—at Key West 5° of excess above the mean temperature. All the western interior participated in the depression, as before, with the whole of the continent westward from Fort Snelling, including California and some parts of New Mexico. The difference at Fort Laramie was 8°.5; at the posts of Oregon 8° to 10°; and in California 3° to 5°, except at the two posts of the south, San Diego and Fort Yuma. At stations in the Rocky Mountains at 47° north latitude the same depression occurred.

In 1838 and 1844 great depressions of temperature occurred at Fort Snelling in January, and in 1823, 1829, 1832, 1835, 1843, and 1853, nearly equal extremes of cold in February. In December, the years 1822, 1831, 1848, and 1849 were so distinguished. The cold of 1838 was in both January and February, but at every other point it occurred only in the latter month, and it was then quite universal, and as severe at the east and south as at Fort Snelling. In 1844 the cold of January was but 4° below the mean at Fort Snelling, and about the same in the lake district, but north and east of New York it was 8° to 10° below. South of St. Louis the month was warmer than usual by nearly 6°.

Of the February extremes that of 1823 appears to have been universal, as it occurs at Fort Jesup, in Florida and South Carolina, and at Fort Sullivan, Maine, in nearly the same degree. That of 1829 was almost equally general, disappearing in Maine and the south of Florida, and having its largest measure at St. Louis; that of 1832 was confined to the northwest, the lake district, and Maine, while the south was 5° to 8° above the mean; that of 1835 was very severe at the southwest and south, causing disastrous frosts in Florida and the semi-tropical districts, but moderate and unimportant over the entire north. In 1843 the greatest non-periodic variation occurred, embracing March, and giving a decreasing temperature from the mean of January through both the following months, over all the south and west. It was less extreme in Florida than the cold of 1835, but much greater everywhere else. In the northeast the minimum was in February, and the depression not so great as elsewhere.

Of the December extremes that of 1831 was very general and severe, embracing Florida, and having the largest measure of depression at almost every point that appears for this month in any year. That of 1848 appears only at the northwest, and at the southwest above Fort Jesup, while at the east and south the temperature is some degrees above the mean. That of 1849 is confined to the northwest alone, and no compensating extreme appears at any point.

This examination of the non-periodic depressions of temperature has been made upon the striking winter extremes because they are more readily traced, and their law should be more easily deducible from such marked cases. The points which may be noticed are, that from this central continental area defined by Fort Snelling, there appears no progressive movement of these extremes, that is, they are not first observed here, and subsequently transferred to another month at the extreme point of any line of distance. That of 1843 continued much longest at the west and southwest, moving in that direction if any movement could be supposed, but there are no other evidences of movement. Those of January generally influenced the western districts uniformly, were interrupted or modified in the lake district, and had some evidence of the existence of compensating temperatures at the southeast and northeast. But in February there were no important indications of this sort, and in December but one appearance of compensating temperature. In 1854 the refrigeration belonged to nearly the whole continent, and there was certainly no evidence of progressive movement.

In examining other series for periods of about thirty years, the number of depressions of temperature amounting to 5° on the monthly mean is generally five for each month, or nearly as many as at Fort Snelling. The entire area east of the Rocky mountains appears liable to an equal number of these variations, and to measures for each more nearly equal than would be found if these variations were the consequence of continental influences alone, and though they have been examined from the point which may be regarded as the maximum district of refrigeration, the oscillations are certainly no greater at Fort Snelling than at posts much less distant from the coasts. The most important inferences are, that the origin of these non-periodic oscillations is exterior to the continent; and that they are central to the belt of temperate climates; that they have no progressive movement; and that they are modified by local influences from land or water surfaces, but not essentially controlled by them in any case.

The extraordinary refrigeration of the winter of 1856 appeared, as in previous cases, to have no important progressive movement. It remained over the great area of the United States below the 45th parallel with singular severity and persistence from late in December to the close of March, and it does not appear to have released the rivers earlier at St. Louis than at Philadelphia.

A most important point in regard to these facts is, that *in no case is it apparent that these cold extremes come from the north*, or are caused by north winds, or an inflection of the polar atmosphere southward. The views previously suggested on this point—that the cold of the lower latitudes in winter was produced mainly by severe and continuous northerly winds, blowing, perhaps, even from the Arctic regions—appear not to be supported in any of these cases. (Humboldt's New Spain; Guyot's Physical Geography, &c.)

MEAN ANNUAL DISTRIBUTION OF HEAT.

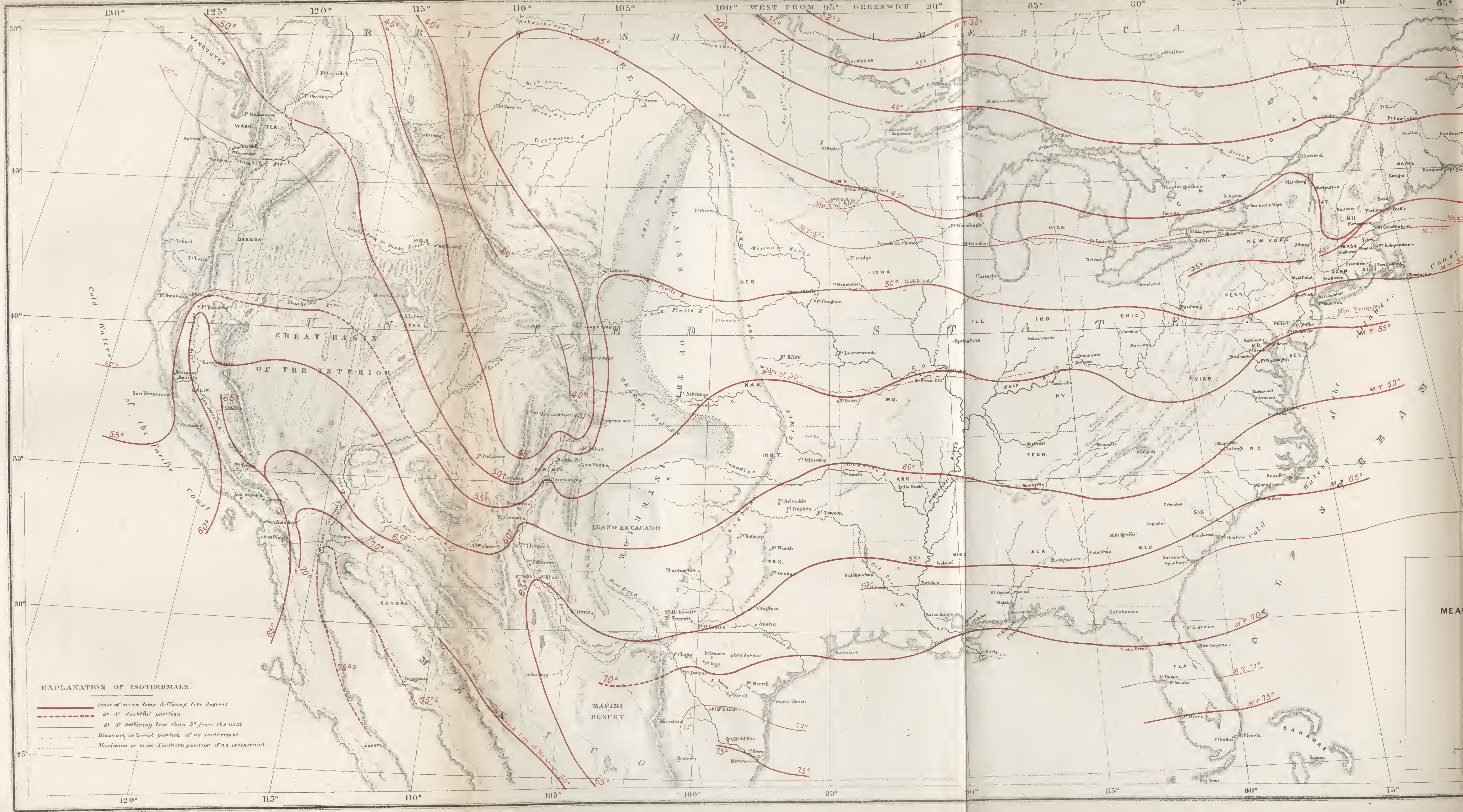
The period of a year is the only perfect natural cycle in the distribution of heat, and there is yet no known curve or progression to higher or lower measures in these mean results, though the irregular

changes of successive years are always occurring, and often large, The parts of the annual curve are equally unalterable, however, and these parts differ so largely that the mean for the year is less clearly defined as a positive or single condition than the parts of the curve for the year which are called the seasons. The summer and winter particularly, have a direct practical significance, which is understood at once when the mean temperature is given, but the yearly mean has not, since it may be made up of contradictory differences,—a warm summer occurring in a year marked by great reduction of temperature for the months not affecting vegetation, perhaps. And as the differences are great here between the warm and the cold months, both in the regular yearly curve, and in the succession of non-periodic changes, the yearly mean is here proportionally further from the desired positive quantity than it is in equable climates.

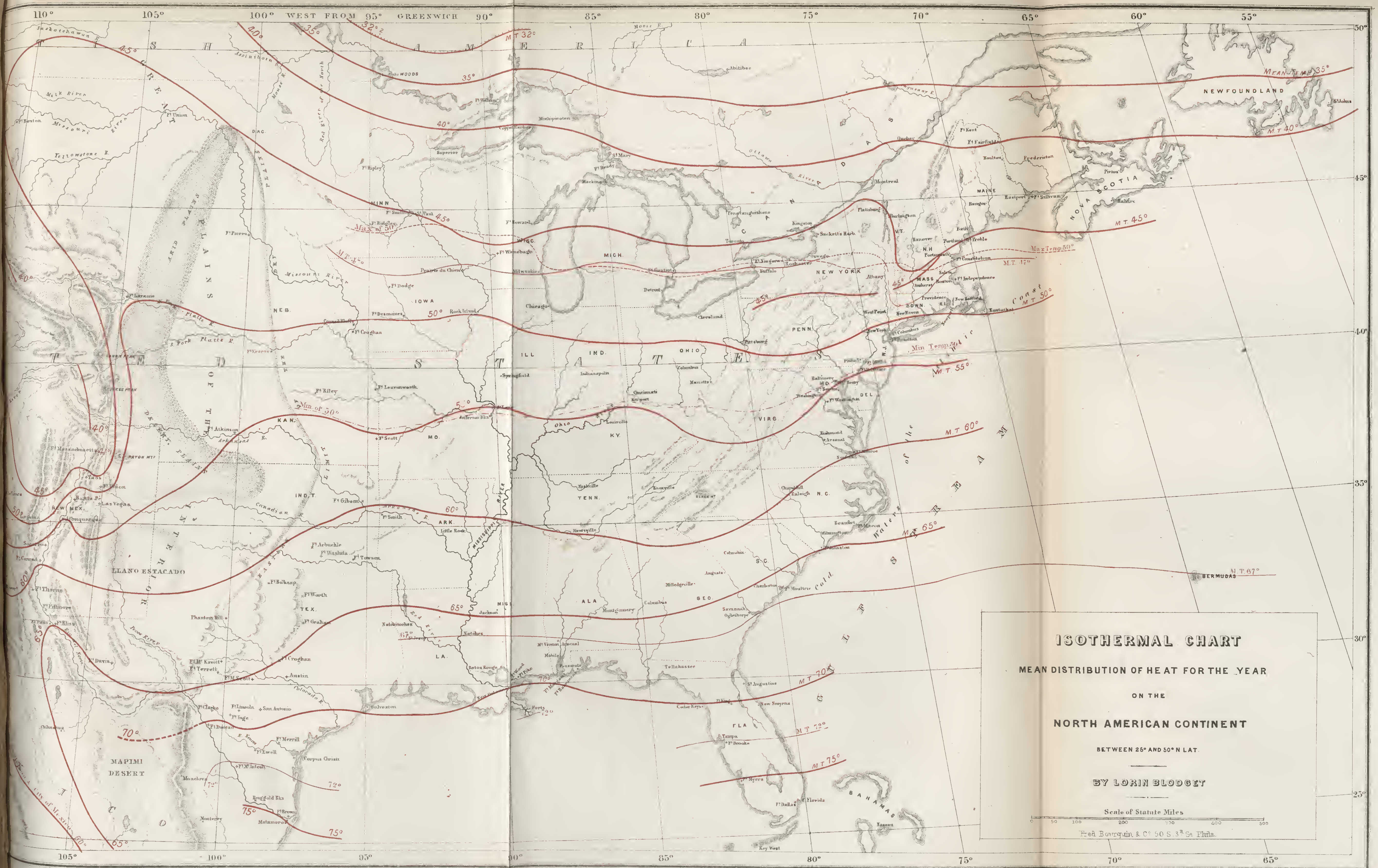
The constants of the yearly curve of temperature are examined in another place as fully as the plan of the present work requires, but it may be said here that the curve has widely different forms—the point where the march for the year cuts the line representing the mean may change from the first of April to the first of May, and from the tenth of October to the tenth of November. The form and position of this curve affect the mean for the year in its character as a fixed quantity for comparison, and to some extent diminish the interest attached to the isothermals for the year. The reference to most of the peculiarities of the annual curve will be left to the more natural association with the constants of climate, however, confining this notice mainly to the features of distribution shown by the yearly summaries, and to the point of direct distribution of heat on latitude, which has always been associated with the summaries for the year.

In the more recent discussions of the fixed distribution of heat by Dove and others, the theoretical normal quantities have been carried through the curve among the months, and the anomaly assigned to the various parts of this continent is measured for each month. In a very valuable review of the Toronto observatories for twelve years, Colonel Sabine gives the measures of departure or difference between these and the normal temperatures for that latitude—43° 40′—as taken from Dove's "Verbreitung der Wärme."* In the remarks relating to the distribution for the spring the differences at that season were seen to be an average of ten degrees for the eastern United States, and the like differences at Toronto for the mean of twelve

* This discussion of the Toronto observations is in the Philosophical Transactions for 1853. A similar discussion of several American series is quite necessary to an intelligible view of the constants of temperature distribution, in latitude, on this continent.



WEST FROM GREENWICH
BRITISH AMERICA
CANADA
UNITED STATES
GREAT BASIN OF THE INTERIOR
GREAT PLAINS OF THE DESERT INTERIOR
LLANO ESTACADO
MAPIMI DESERT
SONORA
MEXICO
Cold Waters of the Pacific Coast
Cold Waters of the Atlantic Coast
GULF STREAM
VANCOUVER
WASH. TER.
OREGON
CALIF.
UTAH
NEW MEX.
NEB.
KAN.
IND. T.
TEX.
MINN.
IOWA
MO.
ARK.
LA.
MISS.
ALA.
TENN.
KY.
ILL.
IND.
OHIO
MICH.
WISC.
PENN.
NEW YORK
VIRG.
N. C.
S. C.
GEO.
FLA.
MD.
DEL.
N. J.
CONN.
MASS.
VT.
N. H.
MAINE
BAHAMAS
San Francisco
Sacramento
Los Angeles
San Diego
Great Salt L.
S. L. City
Santa Fe
Albuquerque
El Paso
Chihuahua
Monterey
Matamoros
Galveston
Austin
San Antonio
Corpus Christi
Natchitoches
Baton Rouge
Natchez
Mobile
Pensacola
Tallahassee
St. Augustine
Key West
Savannah
Charleston
Augusta
Columbia
Milledgeville
Montgomery
Little Rock
Memphis
Nashville
Knoxville
Louisville
Cincinnati
Columbus
Marietta
Indianapolis
Springfield
Chicago
Milwaukee
Detroit
Cleveland
Pittsburg
Buffalo
Rochester
Albany
Toronto
Kingston
Montreal
Quebec
Boston
Providence
New Haven
New York
Philadelphia
Baltimore
Washington
Richmond
Norfolk
Raleigh
Wilmington
Beaufort
Burlington
Portland
Eastport
Bangor
Plattsburg
Sackett's Harb.
Oswego
Superior
Mackinac
St. Marys
Lake of the Woods
Astoria
Columbia River
Humboldt River
Missouri River
Yellowstone R.
Milk River
Platte R.
Arkansas R.
Canadian R.
Red River
Colorado R.
Gila River
Grand River
Green River
Snake River
Ohio River
Mississippi River
Ottawa River
Saskatchewan R.
Assiniboin R.
Moose R.
Pecos River
Rio Grande
Ft. Colville
Ft. Benton
Ft. Union
Ft. Laramie
Ft. Pierre
Ft. Ripley
Ft. Snelling
Ft. Ridgley
Ft. Dodge
Ft. Des Moines
Ft. Kearney
Ft. Riley
Ft. Leavenworth
Ft. Atkinson
Ft. Scott
Ft. Gibson
Ft. Smith
Ft. Arbuckle
Ft. Washita
Ft. Towson
Ft. Belknap
Ft. Worth
Ft. Graham
Ft. Croghan
Ft. McKavett
Ft. Terrett
Ft. M. Scott
Ft. Clarke
Ft. Inge
Ft. Lincoln
Ft. Duncan
Ft. Merrill
Ft. Ewell
Ft. McIntosh
Ft. Brown
Ft. Davis
Ft. Fillmore
Ft. Thorne
Ft. Webster
Ft. Craig
Ft. Conrad
Ft. Defiance
Ft. Massachusetts
Ft. Union
Ft. Yuma
Ft. Tejon
Ft. Miller
Ft. Reading
Ft. Humboldt
Ft. Orford
Ft. Lane
Ft. Dalles
Ft. Vancouver
Ft. Steilacoom
Ft. Okanagan
Ft. Hall
Ft. Howard
Ft. Winnebago
Ft. Crawford
Ft. Brady
Ft. Gratiot
Ft. Mackinac
Ft. Moultrie
Ft. Brooke
Ft. Myers
Ft. Dallas
Ft. Pike
Ft. Wood
Ft. Jessup
Ft. Kent
Ft. Fairfield
Ft. Preble
Ft. Constitution
Ft. Independence
Ft. Columbus
Ft. Hamilton
Ft. McHenry
Ft. Monroe
Ft. Macon
Ft. Moultrie
Ft. Severn
Ft. Washington
West Point
Jefferson Bks.
Prairie du Chien
Rock Island
Council Bluffs
Phantom Hill
Las Vegas
Taos
Ringgold Bks.
Laguna
Socorro
Loreto
Guaymas
Tampa
Cedar Keys
New Smyrna
Florida
Nassau
Quebec
Moultrie
Oglethorpe
Monclova
Mt. Vernon Arsenal
50°
45°
40°
35°
32°
52°.5
55°
60°
65°
70°
72°
75°
75°.2
Min. Temp.
M. T. 32°
M. T. 45°
M. T. 50°
M. T. 55°
M. T. 60°
M. T. 65°
M. T. 70°
M. T. 72°
M. T. 75°
Min. of 50°
Max. of 50°
130°
125°
120°
115°
110°
105°
100°
95°
90°
85°
80°
75°
70°
65°
EXPLANATION OF ISOTHERMALS.
Lines of mean temp. differing five degrees
do. do. doubtful position
do. do. differing less than 5° from the next.
Minimum, or lowest position of an isothermal
Maximum or most Northern position of an isothermal



ISOTHERMAL CHART
MEAN DISTRIBUTION OF HEAT FOR THE YEAR
ON THE
NORTH AMERICAN CONTINENT
BETWEEN 25° AND 50° N LAT.
BY LORIN BLODGET
Scale of Statute Miles
Fred. Bourquin & Co 50 S. 3rd St. Phila.
WEST FROM GREENWICH
NEWFOUNDLAND
NOVA SCOTIA
LLANO ESTACADO
MAPIMI DESERT
BAHAMAS
BERMUDAS

years, from 1841 to 1852, are 10°.9 from March to April, 10° from April to May, and 9°.9 from May to June. The following are the normal temperatures assigned to the latitude of Toronto, 43° 40′, and the measures of departure at Portland, Me., Toronto, Fort Winnebago, and Fort Vancouver,—four points of the line representing the more important districts near this latitude. For the second entry for Fort Winnebago the corrected measures are taken, and the latitude of Fort Vancouver is 45° 30′.

	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Norm. temp.	32.8	34.7	40.1	50.2	58.1	64.6	68.7	68.5	61.5	53.8	43.2	36.0	51.0
Portland	−10.0	−10.2	− 7.6	− 7.3	− 5.3	− 1.5	+ 0.5	− 2.1	− 4.6	− 4.0	− 5.4	− 9.2	− 5.8
Toronto	− 7.0	−11.3	− 9.9	− 9.1	− 6.9	− 3.5	− 2.3	− 2.3	− 3.5	− 8.9	− 6.7	− 9.2	− 6.8
Ft. Winnebago	−13.3	−16.2	− 7.5	− 3.0	− 1.4	+ 1.0	+ 2.2	− 1.2	− 3.7	− 6.9	−11.1	−14.7	− 6.2
do.	−11.3	−14.0	− 5.5	− 1.0	+ 0.6	+ 3.0	+ 4.4	+ 0.8	− 1.7	− 4.9	− 9.1	−12.5	− 4.2
Ft. Vancouver	+ 7.7	+ 7.0	+ 4.0	+ 2.3	+ 0.8	− 2.0	+ 0.0	− 2.9	− 0.7	− 0.5	+ 3.3	+ 0.5	+ 1.6

An approximate reduction of the observations at Fort Winnebago to sea level is made at the rate of a degree for about 380 feet of altitude. It is very evident, from these differences, that the contrast of American and European temperatures in the same latitudes belongs mainly to the low temperature side, and that the winter gives the extreme of difference, or anomaly. It is apparent, too, that this normal scale does not curve sufficiently, particularly for the lower months, to represent the natural or average land climates for all parts of this continent. A series of stations crossing this continent on any parallel would probably give the measures which might be taken as the normal degree of heat, on an equal footing with a like series crossing the entire eastern continent, and the mean of these would be preferable to any quantities derived from theoretical considerations in regard to the amount of heat distributed by the sun's rays on any parallel of latitude.

For the purpose of a rough examination of the American normal measures, the following stations are taken nearly on this line, and about equally distant: Fort Preble, Fort Winnebago, Fort Laramie, and Fort Vancouver. The last two series are for defective periods, or those insufficient to remove the large measures of non-periodic variation which are found in every case, and in each of these December is evidently too cold, and January too warm. The temperatures at Fort Winnebago are reduced to sea level by adding one degree for 380 feet of altitude nearly, or two degrees for the altitude of the post. At Fort Laramie the rule which obtains in Europe for decrease of temperature with the altitude, evidently will not apply at all, as the summer temperatures, particularly, would by this rule of reduction exceed those observed anywhere at sea level near this latitude. A small decrease of heat for the altitude may be assumed, which would add three or

four degrees* to the observed mean temperature for each month. The four series combined, after these corrections, give a curve which differs from the European form by nearly like measures of excess in summer and of diminution in winter; so far confirming the view that not only the low annual mean, but the large differences for the several months belonging to Toronto and other points when compared with the European form, are characteristics of the constant in a great measure, and not anomalies.

Stations.	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Ft. Preble	22.78	24.52	32.53	42.96	52.82	63.11	68.20	66.41	56.91	46.76	37.80	26.80	45.22
Ft. Winnebago	21.52	20.50	34.60	49.20	58.66	67.63	72.95	69 31	59.83	49 90	34.14	23.33	46.80
Ft. Laramie	34.92	36.49	44.70	55.49	64.00	75.23	82.59	81.67	72.10	58.80	43.72	35.87	57.95
Ft. Vancouver	38.90	41.66	44.14	52.55	58.95	62.67	68.71	65.56	60.81	53.30	46.51	36.83	52.54
Mean	29.54	30.79	38.00	49.05	57.61	66.16	72.11	69.74	61.41	51.19	39.54	29.73	49.57
Difference	—2.26	—3.91	—2.10	—1.15	—0.51	+1.56	+3.41	+1.24	—0.09	—1.61	—3.76	—6.27	—1.43

These differences are mainly in the curve of monthly means, and they do not largely affect the annual mean for the latitude as determined by Dove's empirical formulas. The normal mean, which is so far departed from at Toronto, is restored by the introduction of the other series, but the curve of monthly differences remains in marked contrast with those assumed for Europe. If the entire eastern continent were embraced, or the highly heated and dry areas similar to those of the western interior here, it is evident that a higher summer curvature and a lower winter depression would be found for the eastern continent as a whole.

There are too many imperfect data in this comparison to give it more than negative value, or to show that, with existing records, a positive standard cannot be constructed. These series also show that the range of non-periodic variations is everywhere such that an extended period of time is more important than any other element in determining any one of these principal points in regard to the curve of temperature, and its distribution for the year.†

* In the Report on the Military Observations, prepared by the writer, a higher number was used for the correction of the observations at Fort Laramie, but it is evident that the allowance of four degrees made here is still too great rather than too small. The addition to the annual mean which this excess still makes is not undue as the representative of the average of all latitudes, however, as the low plains at the north, and the deserts at the south, would add to the yearly means for the parallels north and south of the high central line at Fort Laramie.

† Dove has, indeed, recognized the fact of the inapplicability of formulas to the distribution of heat in latitude, and in his supplementary report on Isothermal Lines (Report of the British Association for the Advancement of Science, 1848), expressly says that "no formula has been found applicable to all latitudes; in 30° to 40° N. the deviation is always considerable." At present all results are positive, and in some sense isolated; and from the whole mass of them, distributed at all meri-

The isothermals of the chart for the year are generally widely separated for differences of five degrees. East of the 95th meridian they are parallel with the lines of latitude for districts of moderate altitude, except at Lake Superior and on a portion of the Atlantic coast from Fort Monroe to Florida, and at these points they curve northward. West from the 95th meridian those above the 40th parallel of latitude would go northwest, with proper corrections for altitude, and those below, though curving north in the interior, would return in a singular manner along the coast of California to points three or four degrees of latitude south of their position in the Mississippi valley. Between the isothermals of 50° and 55° the same large area occurs on the Pacific coast north of Monterey and San Francisco, which is seen on the thermal charts for spring and autumn, and the isothermal of 50° for the year would go north of the 50th parallel before striking the coast.

The mountainous interior is unquestionably more highly heated

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dians affording distinctions, the ultimate normal scale must be determined. These data are not yet accumulated, but enough matter is at hand to give us the negative fact just indicated, and to show that continental position is of the first importance. The special anomalies presented by the opposite sides of the continents in north temperate latitudes are extreme and irregular, and the thirty-six equidistant points selected by Dove for the formula applied to Toronto, are obviously insufficient as representatives of American temperatures. This is more conspicuously shown in the means for the months than in that for the year, as will be seen by the discussion of the yearly constants of the temperature march in another chapter. A greater proportion of the surface is continental in its temperature curve here than in Europe and Asia,—the plain opening to the west stretching inland there over a great part of Europe, while here it is limited to a narrow belt of the western coast, the first ranges of the mountain systems being so high as to change this equable character entirely.

The first attempts to deduce the law of the distribution of heat in latitude, and to give this distribution a mathematical expression, are thus noticed by Brewster in stating his own celebrated formula. (Edinburgh Journal of Science, 1830, 1831.) "The first who attempted to deduce a general expression for the mean temperature of all latitudes was Tobias Mayer of Gottingen. Assuming that the heat varied as the sine of the latitude he obtained the formula, $T = 58^\circ + 26^\circ \times \overline{\cos. 2 \text{ lat.}}$; in which 58° is the mean temperature at 45° north latitude, and 26° the difference between the temperature of this latitude and the equator. This formula was implicitly adopted by Kirwan in his able work on the mean temperature of the earth, but Humboldt's observations showed that at 63° north latitude it was in error 9° Fahrenheit. Humboldt's beautiful memoir on Isothermal Lines has given a fresh impulse to this research."

Brewster thus states his own formula; "I find that the mean temperature of any place is well represented by *the radius of its parallel of latitude*, or, in geometrical language, that *the temperature varies as the cosine of the latitude.* I have assumed $81\frac{1}{2}^\circ$ as the mean temperature of the equator, and the formula thus becomes, $T = 81\frac{1}{2}^\circ \cos. \text{lat.}$" He then proceeds to compare a large number of places by this formula, and particularly Scoresby's determinations for latitude 78°, which agree with it very accurately. It would make the mean temperature of the pole nearly at zero, Fahrenheit.

than any known district of the same altitude, as may be seen by applying rules of reduction to the means for the year. With any number elsewhere used the mean at Fort Laramie becomes greater than that at Fort Monroe; but Forts Massachusetts and Defiance, in New Mexico, fall below the temperatures of their latitude at the east, and only Santa Fé, with others in the Rio Grande valley, exceed those temperatures. At Salt Lake, Cantonment Loring, and other posts of observation northward, the highest rule of reduction would be required, as at Fort Laramie; and it appears that two or three stations of the greatest altitude in New Mexico alone permit the use of a rate of reduction at all approximating that found to apply in Europe. At Fort Massachusetts a rate of one degree for 475 feet would be required to conform its temperature to that of Fort Monroe in the same latitude on the Atlantic coast; and if the western part of the continent were supposed to be warmer by five degrees of latitude, the reduction would be one degree for 330 feet. But at Fort Laramie and Great Salt Lake the recorded temperatures are already higher than those of either coast at the same parallels, though their altitudes are 4500 and 4350 feet. In the southern part of New Mexico, at an altitude of 4000 to 4500 feet, the temperatures are also nearly as high as at either coast, being, in fact, above those of the Pacific, and below those of the Atlantic, by equal differences.

It is obvious that the surface peculiarities of the elevated districts of that portion of the continent are favorable to a great accumulation of heat, but this arid character may be itself due to the altitude, and the heat might not be greater than elsewhere in the absence of the mountains. With the existing aridity the effect of altitude may only be neutralized, one modification of temperature compensating the other; but there is no reason to suppose that these districts would have less heat than similar positions in Europe, if the country were generally as near the sea level; and in that case all the isothermals would curve northward from the Mississippi valley. The rate of correction for altitudes would then be something more than twice the number of feet for a degree in every case here, than in the rule applicable in central Europe.

These results show that the constitution of the surface and the general configuration—together, perhaps, with the degree of humidity as a possibly separate element—control the temperature in a very great degree, and more, within certain limits, than latitude and altitude. Humboldt observes the increased mean annual temperature of the plateaus of the Cordilleras in tropical regions, and gives the measure of excess over the temperature of mountain declivities at the same heights as 2°.7 to 4°.1. We have no vertical altitudes to com-

pare for the interior posts here, but if the recognized measures of the Atlantic coast of this continent and of Europe are assumed, the excess of temperature on the Rocky mountain plateaus is several times greater than these numbers. There is scarcely any district where the mean temperature at considerable altitudes might be taken for that at sea level for a higher latitude.

The distribution of heat for latitude is directly associated by Humboldt with that for altitude, though there would seem to be little parallelism here with these relations as they exist in Europe. On the Pacific coast here the decrease of temperature with the latitude is very slow, the isothermals of 65° and 50° for the year being separated by at least twenty degrees of latitude; or, using positive points on the coast, San Diego and Sitka, separated by twenty-four and one-third degrees of latitude, differ 16°.6 in mean annual temperature—a decrease of 0°.68 for one degree of latitude. In central Europe this decrease is 0°.9 for one degree of latitude,* but there are no similar points here at or near sea level to compare, except in the Mississippi valley, where the decrease is thirty degrees of temperature for eighteen of latitude—nearly 1°.7 for each. This is also the rate between the extreme posts of the Atlantic coast, including the whole peninsula of Florida, as previously assigned for the distance from Boston to Charleston by Humboldt, who gives in addition, the rate of 1°.6 for the coast from Boston to Labrador.

The interesting features of the relation of these two conditions of distribution in the interior cannot be followed further here, but they deserve attention more minutely. There is very little decrease of temperature for certain measures of latitude and altitude over a large district.

The influence of the cold coast of California appears very decidedly in the position of the isothermals for the year. The cause of this phenomenon has been sufficiently explained in connection with the summer illustration, and it may be disposed of very briefly here. It is a great and remarkable anomaly even when exhibited in the mean temperatures for the year, and the cause of it, with the like cold current and mass of cold water off the coast of South America in the Pacific, together prove the existence of most extensive systems of oceanic circulation and interchange there.

* Cosmos, article Climatology. See also a note in vol. 2, Cosmos, p. 231–2—in which "Vinland" of the Icelandic navigators is referred to, and a very rapid decrease of temperature is assumed for the coast below Boston and Philadelphia: "an interval of 1° of lat. corresponding to a decrease in the mean temperature of about 3°.6, while according to my researches on the system of Isothermal lines in Europe the same decrease of temperature scarcely amounts to half a degree for the same interval." (Asie Centrale, t. iii. p. 227.)

In comparing the two continents of the north temperate latitudes the geography of heat for the year does not show any generic differences for these areas. The special deflections are strongly marked, but the lines may be said to return to like latitudes whenever these special causes of disturbance are absent. The cold coast of the Pacific at the latitude of San Francisco is balanced by the heated deserts of the basin region; the depression at the Rocky mountain plateau by the high temperature of the plains east of it. The Gulf stream pushes the lines northward at the west coasts of Europe, but for the eastern continent generally they correspond better with the average of American positions than would be indicated by the separate seasons. The surface geography of heat for the year is more readily taken from the illustration than that for the divisions of the year, or seasons, and it is less necessary to give its points in detail.

The range of mean temperatures for the year in any series is very large for every part of the United States, and it proves that the period of a year is far from being the whole time embraced by the greater non-periodic variations, and that, whatever the period of these extremes, any single year may be distinguished by several oscillations having the same direction, either above or below the annual mean. Either as months or seasons we may readily point out conspicuous instances. In the series of thirty-three years at Fort Columbus, New York, the year 1836 is distinguished as that of lowest temperature, being four degrees below the general mean. Every month of the year was below the mean, though in unequal measures, and those most extreme were February and October. The previous year and that next following, 1835 and 1837, were the next lowest, each being more than two degrees below. Two months only, and the same months, October and November, of each of these years, were at or above their average temperatures respectively; and with these exceptions the whole period, including the last five months of 1834, or nearly three and a half years, was decidedly below the mean temperature. A similar general result occurred at Fort Snelling for the mean of these years and for their warmer months, but the colder months were variable and the difference for the year less; and this was the case in every part of the United States, with some irregularities, and generally with greater measures of variation than those observed at Fort Snelling.

In the yearly mean there are two groups distinguished by high temperatures, one from 1824 to 1830, inclusive, of which 1825, 1828, and 1830 were the most marked years; and another period from 1844 to 1848, each of the years of which was nearly uniformly above the mean. The first of these periods is the most general, and it is quite conspicuous at the south and west; but the second is irregularly distributed, and the measures of excess belong to shorter periods. The most conspicuous single years at Fort Snelling are 1830 and 1846, and these are everywhere so distinguished, 1825 and 1828 being next. On the Pacific coast, 1853 is marked as the warmest year of the period there observed; and the summer of that year was everywhere much above the average temperature.

The higher temperatures are quite irregularly distributed in respect to the seasons and months, and an analysis of any series would give results analogous to those indicated in the examination of the low temperature extremes. Generally, the coincidences of single months with the seasons and the yearly mean are more numerous than the contrasts for any year, as of eight cases in the period of 33 years at Fort

Columbus, New York, of a mean temperature for the spring months two degrees or more above the general mean, six were coincident with like differences for the summer, autumn, and year; and the same proportions occur in comparing summer and autumn with other seasons and the year. There might be supposed to be two classes of these non-periodic changes, one less frequent and affecting longer periods; and another causing changes above or below the general line of these long periods, and belonging to periods of a month or less.

There are few instances of very high temperatures for any month in a cold year, or of very low monthly means in a warm year; and, though the succession of years is full of extreme contrasts in respect to months, there is some decided conformity in the relations of the successive months of any year of which the mean is particularly cold or warm. This is in part necessary consequence, it is true; but the point of importance is, that if any part of the year is marked by an extreme oscillation it does not find a compensating extreme in that year.

The range of annual means of temperature may be given in continuation of this discussion of distribution in time.

Greatest Range of Annual Means.

		°			°
Houlton, Me.	17 yrs.	5.0	New Orleans	20 yrs.	4.7
Eastport, (Ft. Sullivan)	25 "	3.7	Baton Rouge, La.	24 "	4.2
Portsmouth, N. H.	25 "	6.7	Fort Jesup, La.	23 "	6 6
Salem, Mass.	43 "	6.0	Fort Gibson	27 "	6.9
Providence, R. I.	23 "	5.4	St. Louis	23 "	6.4
New York, (Ft. Columbus)	33 "	7.3	Cincinnati	20 "	5 3
Albany	31 "	7.4	Fort Mackinac	24 "	6.1
Rochester	21 "	5.6	Fort Brady	31 "	7.1
Toronto	15 "	4 1	Fort Crawford	19 "	8.9
Pittsburg	22 "	7.8	Fort Snelling	35 "	8 6†
Baltimore	24 "	4.9	Fort Leavenworth	24 "	8 0
Norfolk	30 "	9.0*	Fort Kearny, Plains	6 "	5.3
Charleston	28 "	6.9	Fort Laramie	6 "	5 8
St. Augustine	20 "	6.7	Fort Brown, Texas	7 "	1.6
Key West	14 "	3.5	San Diego, Cal'a	5 "	2.3
Tampa Bay, Fla.	25 "	4.0	Benicia, Cal'a	6 "	3 2
Pensacola	17 "	3.0	Puget's Sound	6 "	2.0
Arsenal near Mobile	14 "	3.5			

In the interior and at the Pacific coast the periods are too short to give decisive results, yet the range cannot be great there. The large measures at Norfolk and in the central states are remarkable, and it appears to diminish equally northward and southward from this central belt. From Fort Snelling and the central areas of the states west of the lakes to Norfolk there is evidently a belt of maximum range,—which may be interrupted in Ohio, however, since Dr. Hildreth's long series at Marietta gives a range of but 5°,—but which has a range at the two extremities of nearly 10° for any period of twenty-five years. At Toronto the range is but 4°, and though a longer period would probably increase it to five or six, it is evident that the range is less in the lake district than southward, particularly on the Atlantic side of the Alleghanies.

At Cracow and Riga, representing the interior of Europe, the record is almost continuous from 1795 to 1852, and the correspondence of some of the years of high or low temperature is quite decided with like years here, while in other cases the contrasts are equally marked. The years 1824 to 1828 are then above the mean, as they were here; 1830 to 1836 are also above the average, while they are here below it; 1829 was

* 1828 and 1836 compared.

† At Fort Winnebago, central Wisconsin, 1830 and 1836 differ 13°.1; the years here compared at Fort Snelling are 1830 and 1843.

the coldest of 35 years at Riga; 1837 and 1838 the coldest of 27 years at Cracow beginning in 1826. The year 1830, which was so warm here, was at the average there; and the low temperature of February and March, 1843, which rendered the mean of that year below the average in America, was unknown in central Europe.

At several European stations the extreme departures for the months and years of long periods have been calculated by Dove and others, and of these London and Berlin may be taken as the most valuable. At Berlin the period is one hundred and ten years, embracing nearly all the observations of value taken at that city.

Table of maximum range of Temperatures at Berlin from 1719 *to* 1839.

	Warmest.	Date.	Coldest.	Date.	Range.
	°		°		°
Jan.	45.8	1796	5.4	1823	40 4
Feb.	45.1	1763	13.1	1740	29.5
Mch.	49.9	1761	12.3	1785	27.6
Apl.	63.8	1800	40.2	1812	23.6
May	72.6	1811	51.8	1740	20.7
June	82.2	1756	60.4	1733	21.8
July	86.6	1757	65.7	1732	20 9
Aug.	84.4	1807	63 7	1833	20.7
Sept.	74.8	1761	57.4	1733	17.4
Oct.	61.6	1795	41.6	1740	20 0
Nov.	50.0	1767	25 8	1739	24.2
Dec.	44.7	1763	6.8	1788	37.9
Year	59.2	1756	44.3	1740	14.9

At London the Royal Society's Observations embrace a period of 65 years from which the range and dates are similarly derived. The range is also given as observed by Howard at Plaistow, near London, for twenty-five years, 1806 to 1830. The dates in the last case are not given.

Range at London, 65 *years to* 1843; *and Plaistow,* 25 *years.*

	London.			Plaistow.
	Range.	Date of Highest.	Date of Lowest.	Range.
	°			°
Jan.	21.4	1796	1795	14.0
Feb.	13.7	1779	1827	12.3
Mch.	14.8	1780	1789	11.2
Apl.	9.8	1779	1790—1839	8.6
May	11.6	1833	1817—1837	12.0
June	10.2	1842	1816	9.4
July	12.5	1778	1816	8.7
Aug.	10.3	1780	1817	8.9
Sept.	9.6	1815	1803	9.8
Oct.	10.5	1811—1831	1802	12.9
Nov.	10.5	1818	1789—1807	10 2
Dec.	18.8	1806	1788	12.4

The earliest observations taken at Berlin in such shape as to permit the computation of means were in 1718, and there were some interruptions from this date to 1755, after which they were continuous. There is also at Berlin a long series of simple meteorological observations, the earliest of which were made in 1676, but they were not regular at that time. The collection of the Academy of Berlin begins January 1st, 1701, but the observations for several years were only of the wind and weather; the first instrumental observations at regular daily hours were in 1718; in 1721 an interruption occurred, and again in 1751 to 1755, but after this last date the series is complete.

The observers were principally *Gottfried* and *Christfried Kirch*, for some years by *Christine Kirch* after the death of the first named; *Gronau* from 1756 to 1826; *Doctor Brand* for some years about 1826; *Von Bequelin* for twenty years before this date; *Mædler* from 1822 to 1843; and for the last twenty or thirty years *Berghaus, Bouche, August, Von Estfield*, &c. (*Annuaire Meteorologique de France*, 1850.)

X. DISTRIBUTION OF RAIN; IN DIVISIONS FOR EACH SEASON AND THE YEAR, AND IN EXPLANATION OF THE ILLUSTRATIVE CHARTS.

The mode of presenting the principal facts of this distribution is similar to that employed in the representation of the distribution of heat, the districts being defined in a general manner by the mean of the results at stations in similar positions of altitude and exposure. The quantity of rain, through a more direct and simple measurement, is less completely determined than the measure of heat, and the illustration is therefore less exact than in the temperature charts. For many districts it could not now be employed with sufficient precision to answer any requirement of positive science. In western Europe slight differences of altitude very largely affect the quantity of water falling in rain, and for the British islands and the northern coasts of that continent, as well as for the mountainous districts in the south and bordering the Mediterranean, there could scarcely be any accurate general illustration. A portion of the Pacific coast and western interior here shares in these contrasts and this irregularity without doubt, and for these districts any general illustration is only approximate; but for much the larger area of the United States, and for all portions east of the Rocky mountains, the distinguishing feature of the distribution of atmospheric precipitation in rain is its *symmetry and uniformity in amount over large areas.* The quantity has rarely or never any positive relation to the configuration of the surface which would identify it with the distribution of western Europe and the north Pacific coast; and, in contrast with these, it has a diminished quantity at the greater altitudes generally, and the greatest amounts in the districts near the sea level. It also differs from those districts, and from large land areas generally, in having a greater amount in the interior than on the coasts for the same latitudes, at least as far north as the 42d parallel of latitude. These two leading features of the distribution of rain in the United States are of great importance in any attempt at graphic illustration, and in their absence it would scarcely be possible to make such an illustration clear. They are of

even greater importance in the discussion of a mass of results derived from positions widely distributed, and from observations embracing a succession of years, as they then have a symmetrical and associate character which permits the elimination of errors of every sort by combining results, and by treating them as a whole. The correspondence which belongs to like quantities must appear in some intelligible form in comparing results at any two stations, and this conformity, if found to exist, proves at once the reliability of the observations, and the existence of a general symmetry.

It will require but a brief examination of the records and results of observations to show that the graphic illustration undertaken in the charts is a true expression of general symmetry, and that if it is based on accurate records, embracing a sufficient period of time to remove the errors of non-periodic variation, it represents a physical fact as permanent as the lakes and rivers of a continent themselves, since if any slow progression of changes exists affecting the amount of water falling in rain and snow, an equal effect must be produced on rivers, and on bodies of water dependent on rains for their permanence.

The principal defect of these results is in regard to the period of time they embrace. The non-periodic variations of quantity are very great, and a series of many years is required to give a true mean, even for the year, and much more for the months and seasons. For most of the area the range, even for a period of three months, may descend to an entire absence of rain, and for single months this entire absence is quite frequent. For the year, the range is from the present means to less than half that quantity, and with such large departures a short period must necessarily fail to give more than an approximate result. The larger quantities of the eastern United States, and the vicinity of the Gulf particularly, are more affected by imperfect periods than other districts east of the Rocky mountains, and at the west a range of perhaps one-eighth of the quantities assigned to the several districts, should be considered as a possible change of any result by the use of a series of years of observation numbering twenty or more. This possible range, however, does not materially affect the relation of those districts to the eastern United States generally; and as the periods are nearly equal in the new districts, it may not sensibly affect the mutual relations there. In a district having an average of three inches of water falling for any period of three months, the variation will be proportioned to that quantity, and it will be very far less than in a district of the Mississippi valley having fifteen inches for a like period.

The district embraced by the observations is, as said in relation to

the distribution of heat, a complete symmetrical area, occupying nearly all the temperate zone of the continent, and illustrating most of the important facts of rain distribution over such an area. It is far more valuable, for this reason, even in regard to what it outlines, and if the results are not of the rank of positive determinations, than if the measures and illustration were for limited areas and isolated districts. The comparison of districts possessing such diverse features of configuration cannot fail to throw light on the remoter questions in regard to the sources of the supply of moisture to the continents generally, as well as to the sources of supply in this particular case.

The quantities given in the illustration represent the *mean of the areas* in which they are placed, and not, as in the isothermals, the measure at the limiting line. If the mean of the numbers marking two adjacent areas were placed on the line which separates them, the definition would be the same as in the temperature illustration. The quantities in both cases pass into each other by gradual transition, and the abrupt distinctions of shading and of boundary lines are employed only for convenience and clearness of illustration.*

There is, no doubt, some general deficiency in the measurements of the water falling in snow at most American stations, and particularly

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* In Berghaus' Hyetographic or Rain Map, of Europe, these limiting lines—designated *Isohyetoses* for the lines of equal annual quantity, and *Isotherombroses* for lines making the percentage of the quantities for summer on those for the year—are marked with the respective quantities, though the application of these numbers to the *areas enclosed by these lines* is always understood.

The *condition* which is made up of the facts of distribution of rain has no precise descriptive term. Professor Berghaus terms the illustration *hyetographic*, and Johnston employs the same term, which is an appropriate expression for the map or chart itself. There is a term wanted, however, to express the *condition* apart from any illustration, and this condition is clearly one of a fixed and permanent character. The constant quantity of atmospheric precipitation for any area is one which cannot be expressed without the use of the circumlocutory phrase, *the mean of the entire amount of atmospheric precipitation of water in rain and snow, &c.* There is a class of analogous conditions belonging to the atmosphere, of which the first or general one, *aerial*, may be taken as a type, with an apparent improvement in this nomenclature. Their order would then be, the *thermal*, or temperature condition; the *hygrometric* (*hygral?*), the condition of humidity, or of suspended moisture, the *hyetal* (ὑετός, rain), or the general condition of atmospheric precipitation—the rain condition. Next to these is *electrical* as a general atmospheric condition.

Others concur in the use of the root ὑετός, in preference to ὄμβρος, which is used, to some extent, by French writers, and from which we have *ombrometer* (rain-gauge), ombrometry, &c. The shorter word *hyetal* is regarded as standing primarily on the same footing as *hyetographic*, and in its present use the analogy of the atmospheric conditions before alluded to, and the greater facility, perhaps, in introducing a short form of the word, have controlled the choice of *hyetal* over *hyetographic*. These terms are, at least, suggested for the consideration of those interested in the nomenclature of this department of physical science.

at the military posts, and the probabilities are that the results for the winter months fall somewhat below the actual precipitation of these months in every form. In some cases the entry has been made of the depth of snow in inches without converting it into water, and in these cases one-tenth of the recorded depth of snow has been taken as its equivalent in water. This rule is sufficiently near to accuracy for any general purpose, though for the southern latitudes it would give too small, and for extreme northern districts too great a quantity of water. The error of measurements at the military posts is, however, believed to be no greater, on the whole, than the error of records by amateur observers, especially in regard to imperfect measurement of small quantities in winter. The great mass of records of this latter class are obviously deficient in this respect, and with many such observers it is the habit to measure the snows and to interpret this measurement in water by the best rule at their command, while the military records are made under precise regulations well adapted to secure correct results. In the annual summary it is believed that the small winter deficiency is compensated for by a naturally full measurement of actual rains, and by the fractions being usually thrown in favor of full tenths and hundredths in the entries.

In regard to the illustration of this condition by the charts, it may be admitted that farther explanation in its support is desirable, yet we can do no better than accept it as an approximate definition, and such a definition is indispensable to this department of science now, whether it may be made complete or not.

It is a novel result in science to get so far as to fix any of the features of climate as constant quantities, and to assign to them numerical measures. Long series of observations are required in the first place, and subsequently the condensation of these into mean results for a year, or for any definite part of this cycle. This period is a natural and definite cycle, and probably the only one, as no return of years exhibits any evidence that a period is necessary to bring about any more complete climatological result. The point gained is the deduction of a fixed and positive quantity from the endless irregularities of quantity belonging to the heat, moisture, and quantity of rain, as the leading elements of climate; and this regular quantity or average result becomes a determined physical fact,—as much so, in the case of the quantity of rain, as are the lakes and rivers. The lakes and rivers may shrink to half their volume in extreme cases, or they may be temporarily greatly enlarged—if their sources of supply change permanently, they may wholly disappear.

In this sense of permanence as a physical fact we may consider the quantity of rain for a year as a surface stratum, on the Atlantic slope,

and in the Central States, of three and a half feet; which may be diminished to half this quantity, or be increased to twice as great a depth in the extreme years. But with such an average and such a known range we may deal with the quantity as definitely as with a stream of which we know the mean volume and the extremes to which it is liable, and for many departments of engineering these climatological measures are as indispensable as those of river or tide hydrography. It requires some familiarity with the idea that these quantities are capable of being so fixed as to enable us to deal with them in this sense, but the only doubt that will arise when this point is examined, is as to the completeness of the period from which we get results, and as to the accuracy of the measurements.

These two points are, fortunately, capable of self-verification,—the first by the comparison of several points in the same general locality, and therefore giving, or likely to give, without reasonable question, similar results; and the second by comparison of periods covering different dates at the same place, and unequal numbers of years at the same or at similar places. It is easy to see if any are incomplete, and what, if any, are sufficiently complete and similar in results for all practical purposes. As all periods would be but approximations more or less near, however, the result has this general qualification.

In the charts of distribution of rain it is necessary to recognize a permanent division of the area illustrated into two parts, distinguished as those of *periodical*, and of *equally distributed* rains. These are explained in remarking of the illustrations for the separate seasons, to some extent,—the first is that where there are well-defined rainy and dry seasons, and the second is characterized by rains which, though they differ in amount and in frequency very widely, are absolutely non-periodic, and are as likely to fall on one day as another for any month or other period. On the eastern continent the condition in this respect varies in position, if it may so be defined, or the belt of transition is not only very wide, but also movable, and changes position more than here. The winter rains of the whole vicinity of the Mediterranean are not of the profuse character belonging to winter rainy seasons, but they are simply equally distributed rains for so much of the year only. On this continent, however, the boundary or division line is more easily defined and more narrow, and the degree of periodicity, or the partial interruption which appears along the borders of the Gulf of Mexico, is so much less absolute and distinctive than that appearing on the Pacific coast as hardly to form a parallel.

The well-defined region of periodical rains probably begins nearly at Puget's Sound on the north, as it is scarcely recognizable at Sitka. The north of Vancouver's Island has abundant summer rains, and for

all the coast northward, and particularly at Sitka, they are equally abundant with other parts of the year. The summer dry season beginning at Puget's Sound occupies all the coast southward to the tropics, and also a portion of the interior east of the Cascade Mountains; embracing with these the basin of the Columbia River, the most of the Great Basin, and the partial interior district bordering the Gulf of California. The southern part of the Great Basin, with much of New Mexico, is still one of periodic rains, but the summer and autumn are rainy, and other portions of the year dry. The whole district of periodic rains lies west of the Rocky Mountain plateau, except in New Mexico, where it extends eastward, in a modified form, to embrace a part of Texas. Along the borders of this region there is, of course, much variability in precise position, and in some cases the characteristics alternate in successive years,—one year giving well-defined periodic features, and the next having equally distributed rains. In the whole region, also, it would be difficult to make a description intelligible in which specific rainy and dry seasons were recognized, and the division of seasons belonging to the eastern United States serves to describe all the peculiarities satisfactorily.

If our knowledge of China permitted the division of its great area as we now divide the United States, it can scarcely be doubted that conditions similar to those prevailing on the border of the Gulf of Mexico would appear. The tropical rainy season of summer, borders on the equally distributed rains of temperate latitudes in Florida and New Orleans, in such form as to exclude the dry intervening district extending from California to Texas here, and from the Azores to Persia on the eastern continent. The same intrusion of tropical characteristics is believed to exist in China, and by whatever term this mingled tropical and ultra-tropical condition may be designated, it is clearly a generic climatological fact, belonging to the *eastern* areas of the temperate latitudes of both continents, where they border on the tropics. The *western* transition areas of both differ very decidedly. The most appropriate term appears to be *sub-tropical*, and this is applicable to the whole area in which the summer or winter affords an identifiable *rainy season*;—this embraces all the peninsula of Florida with the Atlantic coast of Savannah irregularly; the coast of the Gulf of Mexico westward also irregularly; and lower Louisiana constantly.

This district would appear to deserve the designations assigned it more decidedly than the arid areas on the west of each continent, and it is certainly quite distinct from the district of *periodical rains*, simply. The spring and autumn rains of the transition belt of Europe appear in the same geographical position here, the summer rainy season of the north of Mexico changing to one of autumnal rains mainly at the

lower Rio Grande in Texas,* on the plains of Upper Texas, also, on the plateau near the Great Colorado at Fort Defiance, and near the Sierra Nevada of California. In California generally a strong tendency to this division of the rainy season is disclosed, as has been remarked elsewhere.

The district of periodical rains in Europe occupies all the countries in the vicinity of the Mediterranean, and nearly half of the temperate zone there, or of the whole of the eastern continent. Dove remarks that at Rome after three months of almost perfectly clear weather, only rarely interrupted by a tempest, the rains begin early in October, and last almost without interruption to the first of January. This summer without rain, and autumnal or winter rainy season, belongs to the whole vicinity of the Mediterranean, and to the Atlantic Islands of this latitude,—the Canaries and Azores. There are no tropical rains in any part of this region, or none occurring in the period of greatest heat, as in the case of Florida and at New Orleans, though as these points are not within the tropics, we may designate this approach to tropical conditions as constituting a sub-tropical area. In Germany, however, the greatest quantity of rain is in summer, as it lies in the northern portion of the temperate latitudes, and is similar to the upper part of the Mississippi valley, and to Russia in this feature of distribution.†

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* The autumnal rainy season in Texas is well marked; at Fort Brown the quantity for September is 7.2 inches, October being next at 5.7 inches. For the autumn the quantity is 15.8 inches, or nearly half the sum for the year. Here the quantity for the spring is small, though June has 4.5 inches. At the upper parts of Texas the rainy season for spring is well developed, however, the quantity then exceeding that for autumn, though both seasons there are rainy compared with other parts of the year.

The accounts of travelling parties represent the principal rains of the elevated positions of Texas at the Pecos river as falling in autumn or the late summer, though at Fort Union and Santa Fe the summer is the season of excess. The rains of spring are nearly equally profuse below the 35th parallel.

West of the Rio Grande the rainy summer of Sonora and Chihuahua is thrown forward into the autumn on going northward from Fort Webster, and it falls into the months of August and September equally at Fort Defiance. Here the early spring rains are moderate, and a dry interval follows which occupies much of the summer. The accounts of surveys represent the existence of similar conditions west of the Colorado, and on the eastern slopes of the Sierra Nevada at this latitude. Across this Sierra these rains blend with the divided rainy winter of California, the heaviest branch of which is in autumn. A well marked belt of *Autumn rains* may be laid down for the area just described, and a smaller area may be designated as a belt of profuse spring rains.

† In several notices of the Rain Distribution in Europe Dove traces a connection of the quantities with the monsoons and other atmospheric movements of the Asiatic and Mediterranean coasts, which is stated in reference to the summer rains of Germany as follows; (Dove on Distribution of Rain in the Temperate Zone, *Annalen der*

In all parts of the eastern continent except China, the full tropical districts are very widely separated from those fully conforming to the temperate characteristics, as we recognize them here. This is particularly true of the rains—the full rainy summer of the tropics lying so far south in Africa as scarcely to be known at all, and the equally-distributed rains appearing only in the latitude of the north of France, Germany, and England. This wide transition belt goes to India at the east, and beyond that the facts are now too little known. But in North America this transition belt is relatively much smaller for the observed districts, and east of Texas it is not found at all. The area previously defined as *sub-tropical*, here, is one of *non-periodic* rains nevertheless, and thus are of *equally-distributed* rains in a certain sense, —the difference which gives profusion of quantity being one of degree, or of quantity when they fall, rather than of continuity or cessation. The fact that the interval is often large between the rains of this non-periodic character does not alter the principle of liability, as it may be termed; or the fact that no precise period can at any time be considered certain to be marked by rain, or to be exempt from it.

DISTRIBUTION OF RAIN FOR THE SPRING.

THERE is the same defect to be remarked in this season in regard to its identity as a single or distinctive period that was observed in the temperature distribution. For the interior districts, or central meridians particularly, it enters both winter and summer, and it then has greatly contrasted quantities of rain for the extreme months of March and May. When the observations on the plains of the Rocky mountains shall have been carried over all distinctive portions, and continued for a sufficient time, some useful divisions of the year into other

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Physik, Rosengarten's translation in American Journal of Science, Nov. 1855) "that the winter rains on the outer limits of the tropics, separate, the further we go from them, into two maxima united by slight fallings off, which come together in South Germany into one summer maximum, when the period of temporary rainlessness entirely ceases." As the currents from which he deduces this result as a consequence are not found in the Mississippi valley the summer excess of rain here, which reaches to the 50th parallel at least, must have some other solution.

In the south of Europe and north of Africa the absence of summer rains is forcibly expressed by the number of rainy days given from ten years' record at Algiers, where, for this period, there were 88 rainy days in January, 83 in December, and but a single one in July. The proportions at Lisbon are, for December and July, 55 to 2; at Palermo 37 to 2½. At Rome the fall of rain is ten times greater in October than in July. (Dove.)

WEST FROM GREENWICH
B R I T I S H   A M E R I C A
U N I T E D   S T A T E S
GREAT BASIN OF THE INTERIOR
LLANO ESTACADO
MAPIMI DESERT
M E X I C O
Dry Season of Mexico
Cold Waters of the Pacific Coast
Cold Waters of the Atlantic Coast
G U L F   S T R E A M
BAHAMAS
OREGON
WASH. TER.
CALIF.
UTAH
NEW MEX.
TEX.
KAN.
NEB.
IOWA
MINN.
WISC.
MICH.
ILL.
IND.
OHIO
PENN.
NEW YORK
VIRG.
N. C.
S. C.
GEO.
ALA.
MISS.
LA.
ARK.
MO.
KY.
TENN.
FLA.
IND. T.
MAINE
MEAN


HYETAL OR RAIN CHART
MEAN DISTRIBUTION OF RAIN FOR THE SPRING
ON THE
NORTH AMERICAN CONTINENT
BETWEEN 25° AND 50° N. LAT.
BY LORIN BLODGET
Scale of Statute Miles.
Fred. Bourquin & Co. 50 S. 3d St. Phila.
WEST FROM GREENWICH
NEWFOUNDLAND
NOVA SCOTIA
BERMUDAS
BAHAMAS
GULF STREAM
LLANO ESTACADO
MAPIMI DESERT

periods may be made in this respect, and a more precise knowledge of the peculiarities of the several months may be attained. On the Pacific coast also, the division in rainy and dry seasons is generally the most accurate, and the commencement of the rains and the date of their close are necessary facts. The Rocky mountain districts have equally distributed rains, generally, and these, with all east of the 97th meridian, may be said to possess a very nearly uniform distribution of rain over the three months of spring.

The feature of uniformity just alluded to is one of the most important in this connection, and as it affects the division of seasons, and serves to define the districts where those three months are not an appropriate expression of the desired result, it may be well to examine it here. For stations where the succession of numbers is nearly the same for the months from January forward, there is of course no change of an abrupt character to be anticipated in the succession of days. The period required to eliminate irregularities and extremes is so great that a combination of the results at stations of similar position may furnish a clearer mode of exhibiting the general facts than any list or number singly.*

Taking the measurements in averages for a group of posts in this manner, we may define three districts on the coast of the Atlantic, and the Gulf east of Mobile; one north of Boston, in which the quantity increases from March to May; another from Boston nearly to Norfolk, in which the quantities are equal for these months; another from Norfolk to Pensacola, which has a singular deficiency in April, the spring being a partial dry season between the rainy summer and winter. This peculiarity disappears west of Pensacola, and the quan-

* In the following table the several natural groups referred to are so arranged.

NORTHEASTERN DISTRICT.

	Mch.	Apl.	May.
	°	°	°
Houlton, Me.	1.84	2.83	2.95
Eastport, "	3.16	2.80	2.92
Portland, "	2.92	4.14	5.05
Portsmouth, N. H.	2.16	3.44	3.43
Mean	2.52	3.30	3.59

ATLANTIC COAST, CENTRAL.

	Mch.	Apl.	May.
	°	°	°
Cambridge, Mass.	3.47	3.64	3.74
New Bedford, "	3.60	3.50	3.70
Providence, R. I.	3.62	3.56	3.63
Flatbush, near N. Y.	3.61	3.60	3.78
Philadelphia	3.37	4.11	4.09
Baltimore	3.86	3.56	3.71
New York	3.33	2.80	3.64
Mean	3.45	3.50	3.77

SOUTH ATLANTIC AND GULF COAST.

	Mch.	Apl.	May.
	°	°	°
Charleston (Ft. Moultrie)	4.06	1.75	4.08
Do. Dr. Lining	3.02	1.72	3.66
Savannah	3.06	2.17	5.40
Whitemarsh Isd.	3.31	1.96	4.68
Key West	4.21	1.55	2.58
Fort Brooke	3.37	1.95	3.24
Pensacola	5.87	2.94	4.05
Mean	3.84	2.00	3.96

NORTHWEST INTERIOR.

	Mch.	Apl.	May.
	°	°	°
Fort Snelling	1.30	2.14	3.17
Ft. Leavenworth	1.61	2.74	3.62
Ft. Kearny	1.55	2.68	6.57
Ft. Laramie,	1.37	1.93	5.39
Mean	1.46	2.37	4.69

tities are again equal. Taking the Atlantic coast north of Charleston, it may be said that the distribution for these months is almost absolutely equal—the same quantity of rain may be expected for every day. The extreme districts differ from this equality but little also, and probably the equality of distribution of the diminished quantity at the south and the increased quantity at the north is not affected.

Above and west of New Orleans there is a rapid increase from March to May, but this is not the case east of the Mississippi as far north as Cincinnati, and in a part of the lake district. The differences increase with the distance toward the Rocky Mountains, and on the remote plains the dry spring appears to have identity with the dry season of Mexico for these months. The average quantities for four northwestern posts are nearly doubled from March to April, and again doubled from April to May.

For most parts of the United States east of the Mississippi the distribution is essentially equal, as on the Atlantic coast. There is no partial dry season, and no interruption to the continuity of rains. The whole of this area may, therefore, be designated as an *area of constant precipitation*, and where this is not the case in absolute quantity it differs in proportions only.

The increasing profusion through the spring months in the districts west of the Mississippi is important in many respects, and it gives an appearance of periodicity to the floods of the great rivers of the plains. It is, however, entirely non-periodic in fact, and not similar to the abrupt decline or increase of quantity which characterizes the changes from dry to wet seasons in tropical climates. The notices we have of the origin of the floods of those rivers are meagre and incidental, but yet sufficient to show that they are casual rather than regular, and though largely due to snows in some cases, they are more generally simple floods from profuse spring rains, differing in no essential degree from the like floods of the eastern rivers.

The evaporation, and diffusion of water through sands in these long and shoal rivers is very great, and even the Missouri is said to gain little or none in volume for many hundred miles of its course below the mouth of the Yellowstone.* The Platte, Arkansas, and Canadian, are all of this class of shoal rivers, with their channels often bare in long reaches for months together. The flow of these rivers does not commence in any marked degree until the spring rains set in, and

* "We had occasion to remark the wonderful evaporation from the Missouri, which does not appear to contain more water, nor is its channel wider, than at a distance of 1000 miles nearer its source." Lewis and Clarke (vol. 2, p. 427) of the appearance of the Missouri below the mouth of the Cheyenne, or at Fort Pierre.

then the reasons just given prevent any reliable regularity in their volume.*

The more elevated plateau of the Rocky Mountains has evidently an equality of distribution through the spring months, and it belongs to the division of equally distributed rains, and not to the periodical class. This district has some extension over the mountainous tracts north and west, but in all other places the periodic features prevail. These features are better described in distinguishing the general climate of those districts, and it may only be necessary to say a word here of the chart for that part of the United States.

The dry season of Mexico comes up nearly to the Gila in its complete form, and the whole of New Mexico partakes largely of it. It is doubtful if the measure of three inches assigned to the mountains and more elevated plains will be sustained,—in the immediate valley of the Rio Grande there is but an inch of rain for the three months. The most of the basin region is similarly dry, but on the western slope of the Sierra Nevada March is often profusely rainy, and the rains do not cease until May. The average increases rapidly northward, from two inches at San Diego to near ten at San Francisco, and to fifteen inches at Astoria. It is simply the changing proportion of the rainy season which falls within this period, and the division of spring is really wanting in distinctness and significance as compared with the same period east of the Rocky Mountains.

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* The rivers tributary to the Mississippi from the west generally have a flood in May, and the first decidedly summer-like temperatures of this month are accompanied by profuse and deluging thundershowers. Sometimes these are deferred till June, as at Fort Riley in 1854, and at the posts of the plains generally in 1850. In 1853 the profusion in April and May is quite conspicuous. The mountain snows disappear too irregularly to add certain quantities to the volume of the lower rivers, though they cause most of the floods at the upper parts of these. Fremont found the South Platte, at the 104th meridian, and 4000 feet above the sea, much swollen by melting snows at the first of July.

The records at the military posts on and near these rivers contain few notices of the actual state of the water. At Forts Kearny and Laramie the Platte is apparently always low in April, and irregularly full in the two following months. At Fort Riley the Kansas River had a great flood for the first fifteen days of June, 1855, and Fremont encountered tremendous floods of the same river, in which he lost his natural history collections. Several such floods have been met with by travelling parties, and it is evident that profuse rains fall on the plains to cause them, since this river scarcely reaches to the mountains.

At Fort Atkinson the Arkansas River is often nearly dry in May; on May 30th, 1851, the reporting officer remarks that "the river below is perfectly dry for many miles." In the first days of June of the same year several instances of small rise occurred, but at the close of the month it was again dry.

DISTRIBUTION OF RAIN FOR SUMMER.

The quantity of rain falling in summer in the United States east of the Rocky mountains is perhaps the most decisive distinction of its general climate from that of other similar areas in temperate latitudes, though we can only compare it fully with the western and interior districts of Europe, and some points in Asia. To derive our analogies from Europe alone, we must designate this as a half tropical distribution, and its frequent instances of great profusion, with accompanying high temperatures, often approach the tropical forms of precipitation very closely, if they do not quite institute them for short periods. It has been usual in Europe to designate the summer rains in their percentage on the quantity for the year, and as the interior of Russia is attained, this proportion amounts to nearly fifty per cent. It is generally less, by regular gradation, on lines southwestward from this interior, and on reaching the African districts the summer rains wholly cease. The same designation here would be less expressive of this actual distribution, as it would not represent the actual quantities with their relations for the single period so clearly. The departures here are from tropical or almost tropical districts, with twenty-five to thirty inches of rain for this season, instead of being from districts like those of northern Africa with none. The quantities of the interior would have nearly the same ratios to those for the year, however, as at Fort Snelling the rain of summer is 43 per cent. of the yearly quantity, and at several posts of this vicinity the proportions are nearly the same.

For the whole period of warm months, in which May and September should be included, the quantity of rain distributed over the Mississippi valley is comparatively very great, and there is no great area so far in the interior which presents a similar result. The quantities are absolutely as well as relatively large, and they considerably exceed those of the plains of the Atlantic coast in the same latitudes. The line of fifteen inches for the three months goes only to 38° of latitude on the Atlantic coast, yet it rises nearly to 44° in the Mississippi valley, and occupies a very wide area below the fortieth parallel. The measure of twelve inches is equally more extensive in the interior, though neither of these stretches upon the plains beyond 100° west longitude.

A contrast still more striking in comparison with the precipitation in Europe, is shown in the rapid diminution of these quantities at the more elevated posts generally, particularly in the Alleghanies and in

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GULF STREAM
OREGON
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UTAH
NEW MEX
SONORA
NEB.
KAN
IOWA
MINN.
WISC
MICH
ILL
IND
OHIO
KY
TENN
MO
ARK
TEX
LA
ALA
GEO
FLA
S.C.
N.C.
VIRG
PENN
NEW YORK
MAINE
VT.
N.H.
MASS
CONN
MD
DEL
BAHAMAS
San Francisco
Vancouver
Llano Estacado


HYETAL OR RAIN CHART
MEAN DISTRIBUTION OF RAIN FOR THE SUMMER
ON THE
NORTH AMERICAN CONTINENT
BETWEEN 25° AND 50° N. LAT.
BY LORIN BLODGET
Scale of Statute Miles.
0 100 200 300 400 500
WEST FROM GREENWICH
UNITED STATES
BRITISH AMERICA
CANADA
GREAT PLAINS
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MAPIMI DESERT
MEXICO
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NOVA SCOTIA
BERMUDAS
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GULF STREAM
Waters of the Atlantic Coast
MINN.
WISC.
MICH.
IOWA
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NEB.
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IND. T.
NEW MEX.
FLA.
MAINE
VT.
N.H.
MASS.
CONN.
MD.
DEL.
110° 105° 100° 95° 90° 85° 80° 75° 70° 65° 60° 55°
50° 45° 40° 35° 30° 25°
3 in. 6 in. 8 in. 10 in. 12 in. 15 in. 20 in. 25

Texas; though less so north of New York, where for some part of the elevated interior, the quantity of summer rains is greater than in the plains. But the mountainous districts between the Mississippi valley at St. Louis and Cincinnati, and the Atlantic coast at Norfolk and Baltimore, show the most marked deficiency, which is clearly indicated at Pittsburg and Carlisle. Each of these posts gives but about nine and a half inches for the summer, and still lower proportions exist southward, as is shown by partial records in the interior of Virginia, which give but about eight inches for the summer.*

The lake district also presents a somewhat anomalous result, in comparison with other interior portions at least, as it has less than the valley of the Mississippi in the same latitudes, though nearly the same as the Atlantic coast. The effect of these bodies of water is clearly to diminish the quantity of rain for the whole period of the warm season, though not so strikingly for the three months of summer as for other months. This deficiency appears very clearly in the mean for the spring, and it is conclusive proof that the local evaporation adds little or none to the quantity of rain of these interior districts. The valley of the Mississippi, and its extension in the Ohio valley, strikingly contrast with the rain fall in the lake districts, though this difference is probably due to greater profusion rather than to frequency of rains. The number of days on which rain falls is, indeed, considerably greater at the northern posts of the lake district.

The irregular character of the rains on the plains in summer has been alluded to in connection with the distribution for the spring. They are less in number and more irregular, without having any periodical discontinuance, and the whole immense range, from the thirty-first parallel to the northern boundary of the cultivable latitudes is nearly uniform in this respect. On the Llano Estacado of Texas there is the least rain probably, though next to this is a belt along the Canadian river which has more than other districts, as is apparent from the accounts of those who have traversed it, and from the configuration and cultivable character which the districts at each extremity are known to have. The Wichita mountains extend further west than other elevated and well watered points on the plains, of which there are some near Fort Gibson; and the spurs of the mountains of New Mexico reach eastward at Las Vegas and other points in a district with frequent rains in summer. The whole eastern slope of the Rocky mountains is still generally arid, and the loose soil and rapid

* Reports of the Board of Commissioners of Public Works, &c. This Board established observations at four points,—two at opposite bases of the Alleghanies, near Lewisburg and White Sulphur Springs, and the mean annual quantity for four years was but thirty-six inches, of which that in summer was the least for any season.

evaporation dissipate the rains and diminish the effect of the fall of any certain volume, much below that of a similar rain fall on the retentive surface and soil eastward. On the upper plains of Texas and over all the plains west of 100° of longitude, irrigation is generally necessary to support cultivation which requires the summer for its growth, and in the valleys nearest the mountains at the west it becomes more decidedly so than elsewhere.*

At the western border of these plains the illustration of the rain distribution becomes much less accurate in its expression of the actual condition than before, and it can only be taken as an approximation toward this condition. The whole area is so much broken up by mountains, that great profusion may alternate with entire absence of rain, for the summer at least, on valleys and mountains in the most immediate proximity. Generally, the valleys of New Mexico have little or no rain in summer, and the mountains a large quantity, and this is gathered, as in the mountainous regions of Europe, by local formation of clouds with profuse and perhaps violent rains when no general clouds are formed and no rain falls elsewhere. Such is, to some extent, the case for the whole of the Rocky mountains, and for the higher mountains of the Great Basin, and of California and Oregon. But there is some value in an illustration which expresses a rude average of such results, and the fact that rains are profuse on the high mountains of a district is important to the necessities of occupation and of transit, if not to cultivation. The construction of tanks and reservoirs which may receive accumulations from such sources may be resorted to, and irrigation from temporary mountain streams answers a valuable purpose in the existing cultivation of some localities of New Mexico and Sonora.

The district south of the Gila, including the northern part of Sonora, and the recently acquired territory of northern Mexico, exemplifies this feature in a very striking manner. This region participates in the summer rains of Mexico to its extreme limit near the Gila, and sometimes to Fort Yuma. The mountains in view of this post exhibit frequent profuse and local rains, and these furnish supplies in other-

* Capt. Pope, Topographical Engineers, U. S. A., in his report of Surveys in Texas remarks of the valley of the Pecos river that "very little rain falls in this valley during the months of July and August" (p. 41). "The upper surface of the Llano Estacado is very undulating, and it contains many shallow basins which fill with water during the rainy season,—the months of August and September." (p. 48, Octavo report, 1854-5.) It appears that the autumn rains of the highlands of lower Texas, west of San Antonio, extend northward much further here than at any other point, and constitute a partial district of autumn rains similar to that of the south of Europe.

wise arid districts, of the most abundant character for filling the natural tanks—(*tinaja*, *altas tinajas*, high tanks),* which exist there in singular adaptation to the wants of the country. These already supply many uses in the wants of surveys and expeditions, and in the actual occupations of a permanent population. The clear atmosphere preserves the waters so accumulated from the changes they would undergo in other climates, and they remain fresh until actually exhausted or evaporated.†

The district known to receive the greatest amount of this local precipitation in New Mexico has been designated as receiving an average of fifteen inches for the summer; and ten, eight, and six inches are assigned to surrounding districts of a similar character. At some of the posts very little rain falls, and they are usually located in valleys much below the general level. Nearly all, however, are in districts having a medium fall of rain, and not in the driest localities. Fort Massachusetts, Santa Fé, and others, are much above the general level of the Rio Grande valley; Albuquerque is in a valley wider than usual; and only Socorro, Fort Conrad, and El Paso represent the quantity in the more immediate Rio Grande valley with sufficient accuracy. The quantities of the chart are, therefore, a mean intended to represent the general level as nearly as possible, and they are neither so much as falls on the higher mountains nor so little as the average of the table lands.

The table lands from the Rio Grande to the Colorado along the Gila river have very little rain in summer, and they form the boundary between the regular summer rains of northern Mexico and the characteristic summer rains of the temperature latitudes. Some portion of the mountains at the north of this river exhibit a frequency of rains nearly approaching those of Mexico; and at Fort Yuma the occurrence of rains in July and August, after two or three months of absolute suspension, shows that the summer rains have a partial development at some seasons there. There is a very little, also, at San Diego, and on the southern point of the Sierra Nevada and its

* The term is applied by substitution, its literal signification is a *wide-mouthed jar for catching rain.*

† The writer is indebted to A. B. Gray, Esq., who has surveyed much of this district; to Dr. R. O. Abbott, U. S. A., for some time stationed at Fort Yuma; Lieut. Parke, Top. Eng'rs; Major Steen, and others, for facts of personal observation in this interesting district, on the points referred to in this connection. Of the country on the Gulf of California below Fort Yuma Col. Gray remarks that "water is very scarce, this being the dryest section of country between the Atlantic and Pacific oceans, only raining occasionally in July, August and September. Gray's Report of Surveys, 1855.

prolongations near this point; but in the greater part of California there is no rain in the three months of summer.

On the Sierra Nevada generally there is very little rain in summer; though for this conclusion the general impression derived from official reports, including those of surveys, is the reliance, rather than the positive record of observations of this particular point. In some instances personal observation assures us that the atmosphere is remarkably free from clouds and all forms of precipitation at this season. It appears probable that none of the mountains of California and the coast precipitate any considerable quantity of rain in summer; and the whole class evidently differs very greatly from the mountains of New Mexico in this respect. For other portions of the year these proportions are either partially or wholly reversed, as they certainly are in the winter rainy season of California.

There are anomalous features in the distribution of the summer rains on this part of the continent which cannot yet be properly presented. Its high mountains are generally more dry than those of Europe, and it is only at the highest mountains of New Mexico, at eight to twelve thousand feet above the sea, that we find rains similar to those of the Pyrenees and the northern Alps. The Italian Alps are more abundant in rain than any of this American region, and there is strong evidence that this difference belongs to the general distribution, and not to differences of configuration. The latitudes corresponding to the position of the mountains of California and the Great Basin are found in Africa and not in Europe, and generally this belt, which is a belt of calms at sea, is one of desert areas for the continents of the northern hemisphere.

We know little of the quantity of rain falling in British America and other parts of the north, the measurement at Sitka, Russian America, being almost the only one beyond the Canadas. At this point the quantity of rain in the summer and autumn is very great, and from the evidence afforded by the records of northern Oregon we may suppose the whole of this coast to receive a large precipitation in summer.* How far this extends toward the interior is an important point bearing upon the distribution over the great northern plains of the United States, and for which we have no records north of Forts Laramie and Kearny. Whether the northern ranges of the Rocky

* "The climate of Sitka is warmer than that of Europe on the same parallel. The cold of winter is neither severe nor of long continuance, but the atmosphere is charged with vapors whose condensation occasions almost constant rains. In the month of July the sun is seldom visible more than three or four days, and then only for an instant. The humidity gives astonishing vigor to the vegetation," &c.—*Richardson's Climatology of British America.*

mountains interrupt the rains almost entirely, as they appear to do in the middle latitudes, is not yet ascertainable, and we know only that at the Red River of the North the summer rains are abundant. The measure of ten inches appearing at the extreme posts in that direction may undoubtedly be extended to Lake Winnipeg, and perhaps to the Saskatchawan valley. On the Missouri, however, there is known to be a great deficiency of rain in the summer months at times, and a large part of the great area partially enclosed by its long curve is set down as an arid and uncultivable district by explorers. Its amount of drainage is too small to permit the supposition that it is otherwise, as all the tributaries of the Missouri from the west and south below the Powder Horn river,—or the last of the series near the Yellowstone, and of which that river is the principal,—are small and comparatively unimportant streams, belonging to the class of shoal rivers of the plains, and falling off to a very small volume in summer.*

The extreme quantities of rain measured for this season in the various districts have a great range. These are still more remarkable as departures from the averages than the like measures in the spring, and it is a characteristic of the climate that excessive falls of rain, with phenomena resembling the water spouts at sea, may occur at any point of the interior, and that deluges of rain do frequently fall over large districts as well as at small localities at this season; near New York *twenty inches* (August, 1843) have been measured in a single month of summer. A comparison of the records at several posts for any month marked by an excessive quantity will, however, usually show that the effect is not confined to a small locality. In June, 1853, Forts Pierce, Key West, and Myers, Florida, have a great quantity of rain—nearly 30 inches for the first, 18 for the second, and 25.5 for the last. At Fort Brooke the great measure of 54.6 inches appears in the summer of 1840, but there is no record to compare with south of Fort Monroe, which has 30 inches. At Fort Pike the maximum is 53.8 inches; but

* Lewis and Clark notice particularly the color and high temperature of the waters of these rivers, their quantity of clay sediment, and other evidences that they rise in clay plains, and not in mountains. Later explorers speak of the same characteristics, and notice that they are unexpectedly small. Lewis and Clark's Narrative (vol. 2, p. 392) contains the following remarks: "In the evening they encamped opposite to the entrance of a stream called by the Indians Tongue river. This stream rises in the *Cote Noir*, and is formed of two branches, one having its source with the heads of the Cheyenne, the other with the branches of the Big Horn. The warmth of the waters seems to indicate that the country through which it flows is open and without shade. The water is of a light brown color, very muddy, and nearly milk warm." And at p. 427,—"the Cheyenne discharges but a little water at its mouth, and this resembles that of the Missouri."

as this does not appear elsewhere, the highest quantity at Baton Rouge is taken as the representative of the district generally. All the posts of the Mississippi valley show a very high maximum, and this extreme quantity appears to be directly associated with the tropical temperatures so frequently found there for long periods in summer.

At the lower point of the coast of Texas the rainy summer of the east coast of Mexico approaches both the arid summer of New Mexico and upper Texas, and the equally distributed rains of the eastern United States, which extend over a large share of Texas. At the lower Rio Grande the records of 1850 to 1852 would show a greater identity with New Mexico than with either of the other districts; but in the records subsequent to that time, and particularly for so much of 1855 as has been observed, the leading characteristics are those belonging to the coast at Tampico, or to New Orleans in a wet year. This result places the locality in its most natural association, and shows that it may have a considerable range of climate, at times identified with that of each of the three on which the district borders.

Over much the greater area of temperate latitudes the proportion as well as absolute quantity is greatest in summer, and the quantities for the successive months form a curve with its maximum in one of the summer months. The degree of curvature also corresponds to some extent with the curve of temperature, and where the thermal changes are least the differences disappear, or perhaps the excess is thrown on other months. In Europe, from Paris and the north of Italy, where this summer excess first appears, the increase of differences is rapid north and east, and through Russia in Europe and Asiatic Russia the disproportion increases until it culminates at Nertchinsk and Pekin with *forty times* the quantity in summer which falls in winter; the average for twelve years at the first named place and for seven years at Pekin being 0.32 and 0.53 inches respectively for the three months of winter and 12.1 and 20.5 inches for the summer. For the corresponding districts of this continent, or for the corresponding phenomena here, we must look at positions in the northwest interior, and not near the coast. We find at the interior posts of Forts Snelling, Ripley, and Kearny, for the first post something over five times, for the second six, and for the last nine times the winter quantity falling in the summer. At some stations on the upper Missouri the differences would doubtless be greater, but probably nowhere so great as in Asiatic Russia.

In the eastern United States this summer excess passes, in going southward, into the tropical rainy season of summer without interruption, though in Europe and Asia a wide belt deficient in summer rains lies in the lower temperate latitudes. It is probable that the

east of Asia has the same distribution as the east of the United States, and also that the western part of the North American continent is like Europe; but our readiest comparisons are on the adjacent coasts, and from these the radical difference of the two continents has erroneously been inferred. South of the Alps the summer rains fall off rapidly,—they are of small amount at Naples, and nearly cease in Sicily. In Africa they wholly cease, and this belt of deficiency, or of entire absence in summer, is an immense one, occupying all the north of Africa, the coasts of the Mediterranean, Turkey, Palestine, the Caspian Sea, Arabia, and Persia. Tartary and Mongolia form a debatable ground, of which we yet know nothing from observation, separating the contrasted districts in regard to this distribution.

In the eastern United States the summer excess is least in the latitude of Pekin, which is nearly that of New York, and it only begins at Philadelphia and southward. It is possible that the Japan Islands would correspond to the New England States in regard to summer rains, as they do in latitude and position relative to the continent, but the observed positions on the continent there do not.

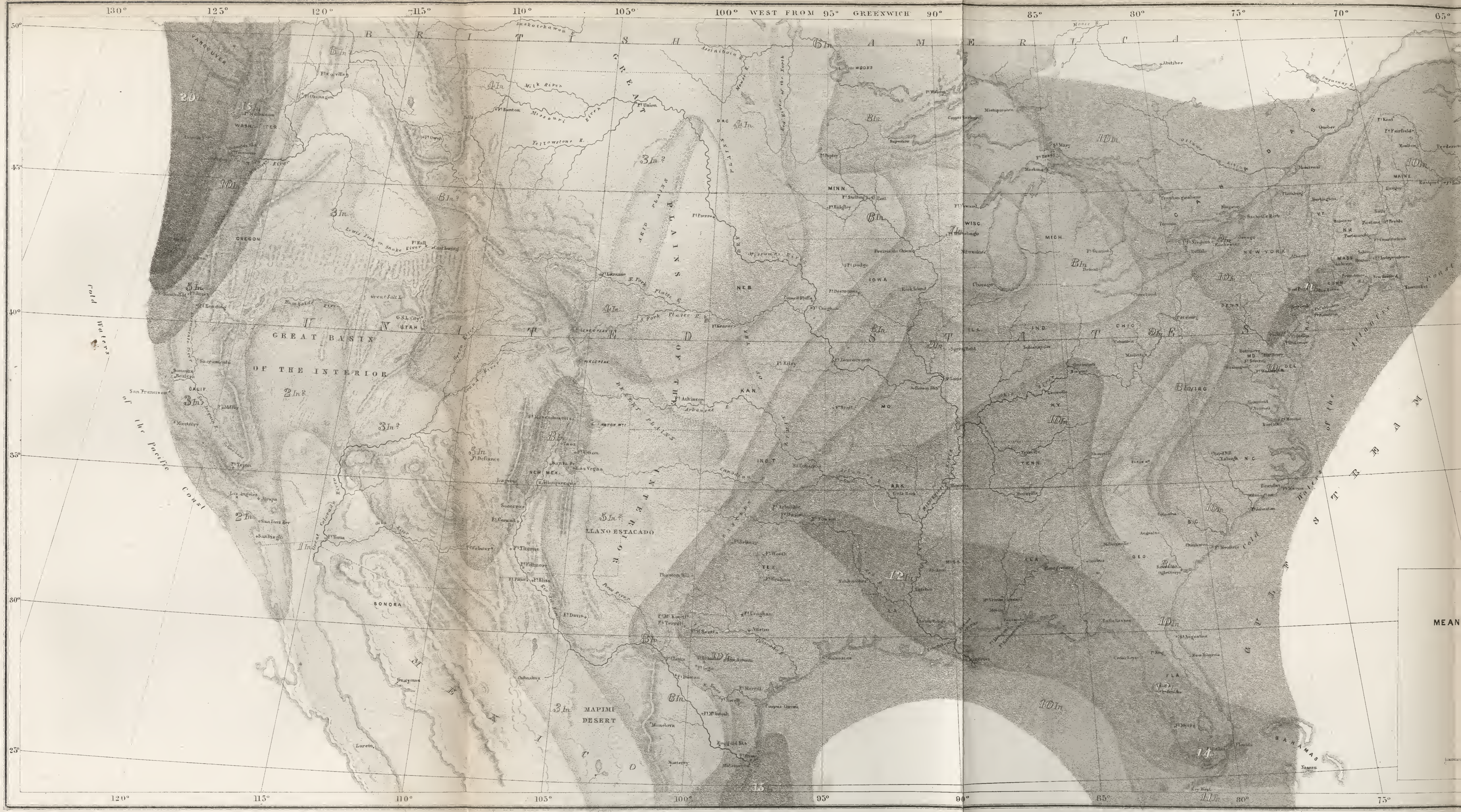
Proceeding south in the eastern United States the summer curve augments rapidly; at Charleston the quantity is nearly three times that for the winter, and a similar proportion holds almost to Key West, though for some points there is a partial development of a winter rainy season. At Key West the summer proportion falls off somewhat, perhaps from local influences, since it again appears at Havana, and is known to belong to the Mexican coast in the same latitude, and also to the Mexican interior. In the southern Atlantic States the excess belongs to the summer months and to September, rather than to the early summer and to May, as on the plains west of the Mississippi. August is here the month of greatest quantity, and June is that of greatest quantity in the west and interior. A similar tendency is developed in the Asiatic stations, as is shown by comparing the points nearest the sea on the east with those in the interior of the continent;—Pekin and Ajansk, with Koursk and Lougan in the plain of the Black Sea. At Canton and Macao this excess in summer is fully maintained, and it somewhat exceeds that at Havana and the south of Florida, points of similar latitude and similar position relative to the continent. The mean of fourteen years' observation at Macao gives 0.6 inches for January, and 12.1 for May. At midsummer there is a slight falling off from the quantities of May and June, and a similar tendency is disclosed at points on the coast of Florida having the greatest excess of rain. Aside from local and easily explained peculiarities there is much resemblance between the coasts of the Gulf of Mexico and the China Sea.

DISTRIBUTION OF PRECIPITATION FOR THE AUTUMN.

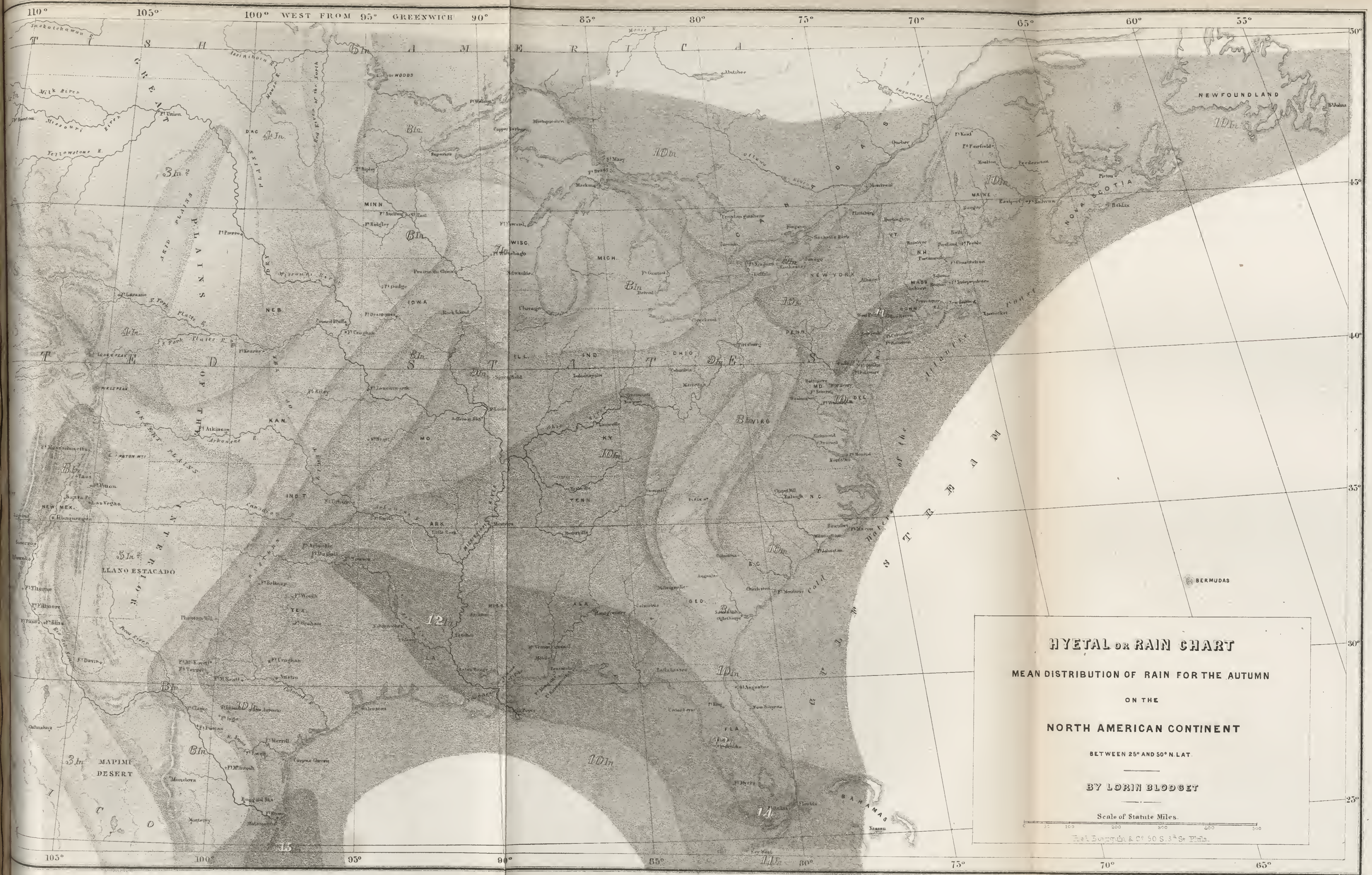
For the area where the graphic illustration of rain distribution is most clearly expressive of the actual condition—that east of the Rocky mountains—there is less contrast in the quantities for the various districts in this than in any other season, or period of three months. The measure of ten inches, which is so general for all the charts on the Atlantic coast, belongs to a much larger proportion of this area than in other cases, and there are but two or three small districts having larger measures. The three warmer points of the Gulf coast which are half tropical, and which so uniformly have a large precipitation for some part of the year, all now go nearly as high as fifteen inches, though the records of southern Florida and of the posts near New Orleans are for imperfect periods. At the mouth of the Rio Grande the quantity is clearly greater than at any other season, and this appears to be caused by an extension of the rainy season of summer into September and October, or rather by its occurrence at that point in these months principally, instead of being confined to the summer months proper, as in some parts of Mexico. On all the eastern coast of Mexico September is one of the rainy months, and at Vera Cruz the quantity falling in it is nearly as great as in any other month.

On the coast of Oregon the periodical rains occupy a large share of the three months, beginning before the close of September and becoming quite continuous through the latter part of October and in November. At two posts of the immediate coast, Fort Orford and Astoria, the quantity is twenty inches, and at the partially interior post of Steilacoom, fifteen inches. At Sitka the mean for two years is thirty four inches, and it is evident that the humidity increases rapidly along the whole coast from California northward. The periods are not sufficient to give reliable mean quantities, however, and it can only be generally stated that the Pacific coast north of 42° of latitude is characterized by profuse precipitation through at least half of the three months of autumn.

The districts deficient in rain at this season are nearly the same as at other seasons. The plains, with New Mexico, the Great Basin, and California, are all comparatively dry. In most of California, there is no rain in September, and for all parts south of San Francisco none in October. In this northern half the rains commence in October, though irregularly, and in the south in like manner in November. In California these rains are rarely continuous for these months, however, or reliable in successive years. They sometimes commence in



130°
125°
120°
115°
110°
105°
100° WEST FROM 95° GREENWICH 90°
85°
80°
75°
70°
65°
B R I T I S H A M E R I C A
GREAT PLAINS
WASHINGTON
OREGON
CALIF
UTAH
GREAT BASIN OF THE INTERIOR
NEB
KAN
IOWA
MINN
WISC
MICH
MO
ARK
TENN
KY
OHIO
IND
ILL
PENN
NEW YORK
MAINE
VT
NH
MASS
CONN
MD
DEL
N.C.
S.C.
GEO
ALA
MISS
LA
TEX
FLA
IND.T.
NEW MEX
LLANO ESTACADO
MAPIMI DESERT
SONORA
M E X I C O
DESERT PLAINS OF THE INTERIOR
U N I T E D S T A T E S
Cold Waters of the Pacific Coast
Cold Waters of the Atlantic Coast
G U L F S T R E A M
BAHAMAS
San Francisco
Monterey
Los Angeles
G.S.L. City
Great Salt L.
Santa Fe
Albuquerque
Las Vegas
Fort Union
Missouri River
Yellowstone R.
Milk River
Montreal
Quebec
Galveston
Key West
20 In.
15 In.
10 In.
6 In.
5 In.
4 In.
3 In.
2 In.
1 In.
8 In.
12 In.
14
15
MEAN


HYETAL or RAIN CHART
MEAN DISTRIBUTION OF RAIN FOR THE AUTUMN
ON THE
NORTH AMERICAN CONTINENT
BETWEEN 25° AND 50° N. LAT.
BY LORIN BLODGET
Scale of Statute Miles.
WEST FROM GREENWICH
NEWFOUNDLAND
NOVA SCOTIA
BERMUDAS
LLANO ESTACADO
MAPIMI DESERT
NEW YORK
BAHAMAS

the form of the more perfectly developed periodical rains of the northern coast, or of this district for December and March, yet they may be as extremely irregular as in any other part of the United States. If the distinction of this season were there the same as it substantially is for the eastern United States, or defined by declining temperature and the cessation of vegetable growths, there would be an almost entire absence of rain belonging to it over the great interior and California districts. The heat of summer is, in fact, the close of vegetation for most of this region because of its aridity, and the autumn has little in common with that of the Atlantic States.

In the Great Basin, or in its best known portion near Salt Lake, and in New Mexico, the rains of these three months are quite equally distributed, and the actual quantities do not differ greatly from those at other seasons. The snows are early, also, occurring quite as soon as in the lake district of the east, though their quantity is unimportant except in the highest mountain ranges. This district has some forms of precipitation, either as cloud formation alone, or as slight storms of rain or snow on the mountains, during the most of the periods of these months; and though practically dry, as every season except winter is, it is so only by general deficiency of atmospheric moisture, and not in consequence of any periodical distribution. This portion of the interior is, technically, a district of constant precipitation.

On the plains the distribution of rain is somewhat the same as in the first two months of spring in respect to the frequency of long periods of fine weather, and in the generally small quantity falling. The autumnal periods of absence of rain are longer, however, and more general, reaching eastward over most of the Atlantic States, and sometimes characterizing nearly the whole area. The softened temperature and peculiar character of these dry autumnal periods form one of the most striking features of contrast with the same season in Europe, and these peculiarities almost always continue until broken up by a general rain. The steady atmospheric movement from the west which belongs to the middle latitudes of the United States, apparently favors the extension of these periods both in time and space. Dry and serene periods on the plains become even more dry and serene as the mass of atmosphere moves eastward at this season, and the changes of temperature are not only less, but there is also less rain to be precipitated by these changes.

These dry periods are fewer east of the plains, and the number of days on which rain or snow falls increases toward the Atlantic coast. Their characteristic features, as shown in the calms of several days' continuance popularly known as the *Indian summer*, are, however,

still well defined, particularly in central New York and Canada; but they are shorter, and they alternate with intervals of slow but constant rains, embracing many successive days.

In most of the Atlantic States, and particularly in the central districts, or from New York to Norfolk, the precipitation of autumn is mainly in general storms of two or three days' duration. The number of days of rain is less than at the northeast, and the intervals are usually serene. The actual depth of water falling is strikingly regular for the successive days throughout, as before remarked, and the proportion for each of the months quite uniform. There is some appearance of deficiency in September for part of the northern districts, at the military posts of the New England States; but the most extended periods of record from other sources, as at New Bedford, Massachusetts; Albany, Utica, and Rochester, N. Y.; as well as the very complete periods at Fort Columbus, West Point, &c., show no noticeable diminution for this month. There is also no excess apparent in it for any point north of Norfolk in the eastern States.

The autumnal distribution of rain in Florida is more difficult of explanation than that for any other district, from its very great irregularity, and from the inadequacy of the periods of time during which observations have been made, to reduce the prominence of the differences arising from this irregularity, and to establish any definite rule of the relations of the several months. The distribution at the posts of the south, in the Carolinas and Georgia, is also extremely irregular, and it appears that the non-periodic variations are greater here, in regard to the quantity of rain in these months, than almost anywhere else. The regular distribution of quantities at Norfolk becomes much broken up at Charleston, where each of the autumn months frequently falls off to an almost entire absence of rain. The mean of September is here also much the greatest, and that for November least. At Savannah a series of fourteen years' observation by Dr. Posey, and one at the military post shows the same distribution. Nearly all the posts of eastern Florida, and of the peninsula, give a like result; and a tendency to periodicity, or to a division of seasons in this respect, is certainly apparent for these short periods. The following numbers illustrate this point:

Stations.	Sep. °	Oct. °	Nov. °	Stations.	Sep. °	Oct. °	Nov. °
Charleston, Dr. Lining	6.34	3.04	2.23	Fort Myers . . .	9.54	1.37	0.96
Charleston (Fort) .	5.83	2.44	1.79	Fort Brooke . .	6.23	2.40	2.00
Savannah . . .	4.29	2.40	1.50	Fort Meade . .	4.85	1.50	0.56
Savannah (Bks.) .	4.07	1.95	1.19	Cedar Keys . .	4.97	3.80	3.17
St. Augustine (Fort) .	5.85	2.42	1.29	Pensacola (Fort) .	5.25	2.41	6.05
Fort Shannon . .	4.33	3.78	1.60	Mobile (Ars'l.) . .	3.05	3.92	6.18
Fort Pierce . . .	9 27	5.36	2.21	Baton Rouge . .	3.91	2.67	5.90
Key West . . .	6.12	4.84	1.82	New Orleans . .	3.51	3.37	3.91

From these results it is evident that a comparatively dry season succeeds the profuse rains of August and September in Florida, and the portion of the Atlantic States bordering it, and also that this dry season *does not extend westward beyond Pensacola.* The periods at this point, and at Mobile, (Mount Vernon Arsenal,) are for ten to fifteen years each; and if the features there were really analogous to those of eastern Florida, the fact could not fail to appear in the comparison of the similar dates embraced by these records.

By reference to the general tables it will be seen that there is a marked tendency toward the development of a winter dry season, even in the States next to Florida, and that in southern Florida this is quite decided and almost as fully developed as in the recognized tropical climates. As before remarked, however, there are great irregularities, and often quite contradictory results for single years. Thus at Charleston (Ft. Moultrie) there is one instance of nearly eight inches in October; at Savannah one of seven and a half inches; at St. Augustine (Ft. Marion) instances of six inches; at Fort Pierce ten; at Key West one of nine, and one of fourteen inches. The quantities in November are also often considerable, and all these alternate with months of none or of very little. In September these instances of profuse rains are more numerous and more extreme, in some cases exceeding twenty inches. The most prominent feature of rain distribution in Florida, in distinction from other parts of the United States, is this great irregularity, which prevents us from getting clear general views from periods embracing but two or three, or a few years.

The records at Pensacola (Fort Barrancas) and at Mobile are also characterized by great irregularities, and here a *winter rainy season* is in process of development. The minimum is in August, September, or October, from which point the quantities increase very much in November in every case, remaining large through every winter month. Comparing Baton Rouge, as the central point of this district of profuse winter rains, with the posts of southern Florida, the contrast is at once apparent. Though this belongs more appropriately to the winter distribution, a citation may be made here to illustrate the characteristics of the autumn, in which season these changes first occur.

	Sept. °	Oct. °	Nov. °	Dec. °	Jan. °
Key West, Florida . .	6.12	4.84	1.82	2.15	2.20
Fort Meade, Florida . .	4.85	1.50	0.56	1.79	1.07
Mt. Vernon Arsenal, Ala. .	3.05	3.92	6.18	5.25	6.80
Baton Rouge, Louisiana .	3.91	2.67	5.90	5.23	5.26
New Orleans, Louisiana* .	3.51	3.37	3.91	3.78	4.61

* Dr. Barton's Table and Report from the Sanitary Commission of New Orleans. At Key West the mean of the two series taken there is given.

The first approach of this dry season in Florida is made in October, and from the minimum, which appears to occur in November, there is a partial resumption of the rains apparent in midwinter, to be followed by other months of less rain. But as a whole, the winter, from October forward, is a dry season on the peninsula of Florida, and to some extent on the south Atlantic coast. At the west, along the Gulf coast, however, a reverse condition obtains, and a rainy season of the most marked features belongs to the vicinity of the lower Mississippi, apparently reaching up in the interior to Memphis.*

The irregularities in this succession of the months are not sufficient to change the character of this district as one of constant precipitation, however, nor is it rigidly any the less identified with that of equally distributed rains in the general sense in which the term is used. But in Florida a different designation applies, though we are yet unable to say precisely what that designation should be. It appears to be a climate ordinarily of a division into two principal seasons in regard to the rains, the wet summer and the dry winter, yet either may be interrupted by extremes of an opposite character much greater than those occurring in any other known district.

The proportion of the autumnal precipitation which falls in snow is quite large for some part of the northern and eastern United States, and for the mountainous regions of the interior and Pacific coast. Snows occur in rare instances north of 42° of latitude in September; in October they are frequent to this point, and they may reach to the 38th parallel. In November they rarely go much farther south, but they remain upon the ground in the more northern districts, and sometimes as far south as the first named latitude, through much of the winter. The elevated districts near the lakes and toward the Atlantic, as in the highlands of New York and New England, are most abundant in snow; and the quantity of precipitation is maintained in this form through the winter months here, while it appears to fall off, from deficiency of atmospheric moisture, west of the lakes and on the great plains. At Fort Snelling November has only about one-third as much as September, while at Fort Brady there is much less difference, and in New York generally there is no difference in the quantities.

There are too few observations to warrant any examination of the quantity of snow in the great mountainous districts of the interior and Pacific slope, and the illustrations of the chart for those districts

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* At Vicksburg, for fifteen years, October is the month of least rain and January of the greatest.—(Pub. Tables of A. L. Hatch.) At Huntsville, Alabama, Rev. Dr. Allan's observations give the same result; as also others at Natchez and Jackson, Mississippi, and those of Professor Hamilton at Nashville, Tennessee. See the tables in the present work for those points.

are approximations only, derived from such observations as exist, and from the best analogies afforded by the configuration.

DISTRIBUTION OF PRECIPITATION IN RAIN AND SNOW FOR THE WINTER.

THE influence of heat simply on the quantity of water falling in rain and snow becomes most fully developed in the winter precipitation of the interior, where it is evident that below a certain point of temperature very little moisture remains in the atmosphere, and the quantity falling in rain and snow is very small. The measurements for this interior are too few to give the absolute mean quantities here with precision, but they cannot vary much from those entered on the chart. At Fort Snelling the period is sufficient to give a very reliable result, however, and those at Forts Leavenworth, Kearny and Laramie cannot be far from true mean quantities. North of this line, on the plains, it is only known that the winter precipitation, in every form, becomes gradually less, and it is thought to be least on the plains of the upper Missouri.

In illustration of this general feature of very little interior precipitation in winter, comparison with the interior districts of Siberia may be made, and on these last the rate of diminution on any line from western Europe is found to be very rapid, and the extreme point of the interior to have very little, if not to be quite destitute of winter precipitation. Such a district of absolute aridity is said to exist there, and in referring to the climatology of the plains of British and Russian America, Richardson cites it, and remarks a possibly parallel case near the Yukon river, at the western limits of British America. It is here, as in Asia, a barren plateau on which no water is found.*

The quantity of snow is small on all the northern prairie slope of the Rocky mountains, and the prairies of the Saskatchawan and upper Missouri, in a line with Fort Union, (of the Missouri,) Fort Pierre, and Fort Kearny, appear to afford the minimum of winter precipitation in every form. The snows are more abundant at the Red River of the North than west of it on the plains, and as the lake district is traversed from the west they steadily increase, with the occasional occurrence of profuse winter rains, to the Atlantic coast. Through

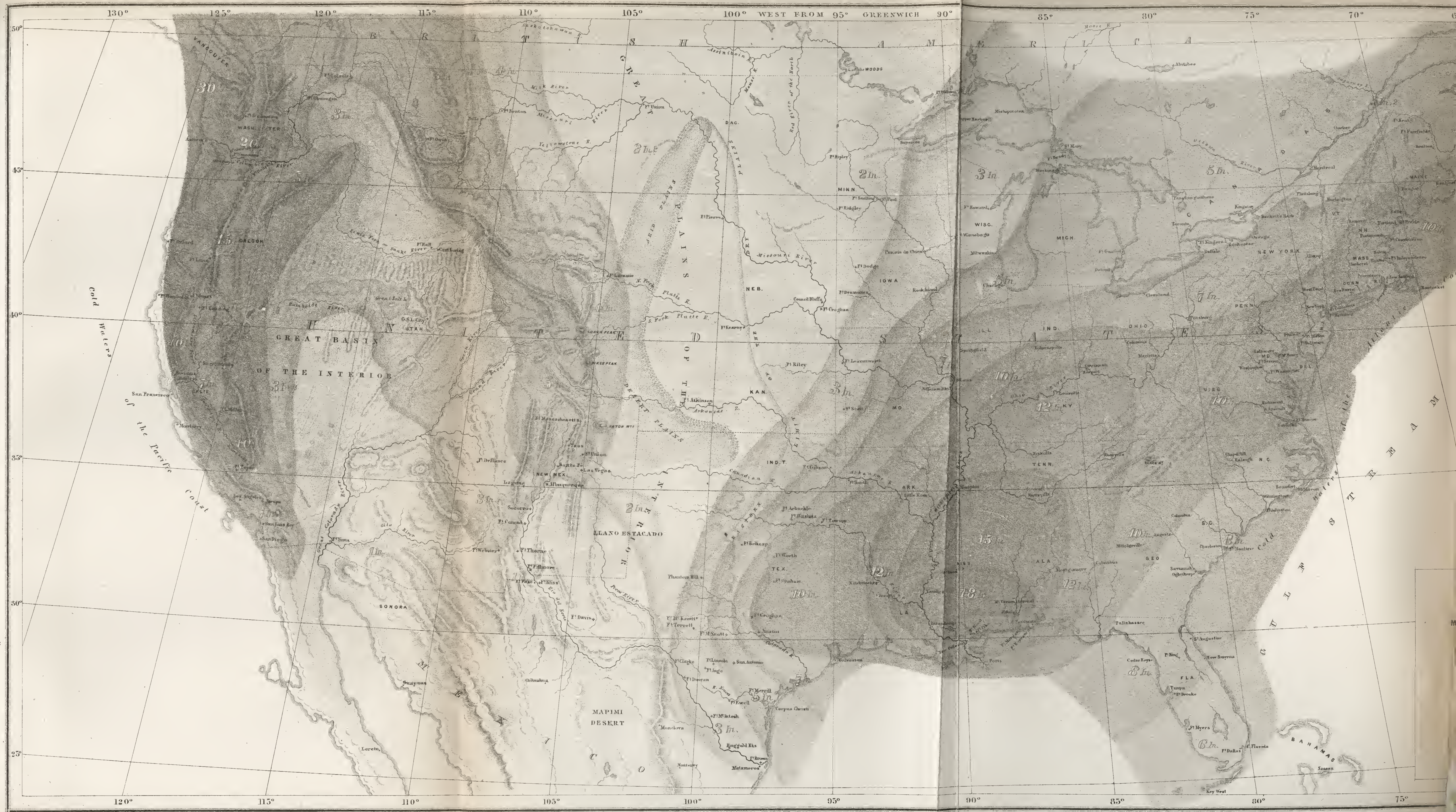
* "Between the Yukon and Lewis rivers there is a barren plateau which the Indians cross in four days, but on which they find no water;"—and in a note its similarity to that in Siberia is remarked, "for it can scarcely be, in so rigorous a climate, that melting snow, if it exists, should not leave pools of water all summer."—*Richardson's Arctic Expedition.*

all this lake district, with that of the northern Atlantic coast, rains and snows are interspersed through all the winter months, and the changes of temperature are such as sometimes to render these rains as profuse as those of any other season. Winter rains are more rare on the plains, in the same latitudes, though not wholly wanting, except, perhaps, on the high plains west and northwest of Lake Superior. Here the winter is quite uniform and rigid, and it is characterized by great aridity, as well as by steady low temperature.*

As an associated general feature of the chart the appearance of the greater shadings on the ocean coasts is quite conspicuous in winter, though there is one exception, which has been noticed in comparing the quantities for the autumn, in the diminished quantities in Florida and the south Atlantic States. This winter dry season appears also in lower Texas. The greater quantities on the coasts at this season, afford the only features of identity of the distribution of rain on this part of the continent with that characteristic of Europe, and that which has, hitherto, as in Berghaus' and Johnston's charts, been assigned to this continent from the analogies afforded by better known land areas. It has been seen how largely the distribution for the seasons already illustrated, differed from that based on principles which assign to coasts, and to the nearest mountain ranges, the leading agency in causing precipitation. In previous cases, the Alleghanies more frequently cause deficiency than excess, and now, although the districts near the coast have more rain than the interior, there still appears to be no increase due to the presence of any of the elevations of the Appalachian chain. Upper Virginia contrasts with the Ohio valley, and with the plain at Baltimore and Norfolk, in the same manner as in summer, though not to the same degree. At the first uplifts of the southern extremity of these hills, in Alabama and Mississippi, there is probably some increase in the quantity of rain, though we are yet unable to decide the point satisfactorily.

The maximum for the eastern United States falls again in the atmospheric basin of the lower Mississippi, and where a partial development of a winter rainy season occurs. In the remarks relating to the autumn precipitation these winter rains and their partial periodicity

* Richardson makes frequent reference to the "dead winter months" at the Hudson's Bay Company's posts of British America, beyond the lake district. At Penetanguishene, Lake Huron, he says: "In December much snow falls. A great fall of snow takes place in February, and there is usually a temporary thaw about the end of the month, accompanied by heavy rain and occasionally by thunder." Of the winter in Minnesota a recent writer says, (Bond's Minnesota and its Resources;) "The most remarkable characteristic of the winter climate of Minnesota is its great dryness—there being an almost total absence of rain and moisture. Not more than one heavy rain storm has occurred within its limits during the last ten years."



WEST FROM 95° GREENWICH
GREAT BASIN OF THE INTERIOR
GREAT PLAINS OF THE INTERIOR
LLANO ESTACADO
MAPIMI DESERT
SONORA
Cold Waters of the Pacific Coast
San Francisco
OREGON
UTAH
NEW MEX.
NEB.
KAN.
IND. T.
TEX.
MINN.
IOWA
MO.
ARK.
LA.
WISC.
MICH.
ILL.
IND.
OHIO
KY.
TENN.
ALA.
GEO.
FLA.
S.C.
N.C.
PENN.
NEW YORK
BAHAMAS

HYETAL OR RAIN CHART
MEAN DISTRIBUTION OF RAIN FOR THE WINTER
ON THE
NORTH AMERICAN CONTINENT
BETWEEN 25° AND 50° N. LAT.
BY LORIN BLODGET
Scale of Statute Miles.
WEST FROM GREENWICH
NEWFOUNDLAND
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MISS.
LA
TEX.
FLA.
IND. T
NEW MEX.
LLANO ESTACADO
MAPIMI DESERT
GREAT PLAINS
GULF STREAM
BERMUDAS
BAHAMAS

were noticed. The contrast with Florida and lower Texas which they exhibit is perhaps the most striking peculiarity disclosed by the chart, or by the illustration of the observations. It is difficult to account for these features satisfactorily upon any received principles of winter distribution of atmospheric humidity, unless we suppose these extreme southern points to be more nearly assimilated to tropical districts in regard to rain than they are in temperature. In truth, they lie in the neutral latitudes, which afford the anomalies of Africa and Asia, and which appear to be controlled by the configuration of the districts, and by accidental or anomalous atmospheric movements resulting from peculiar relations of the sea and land areas. The profuse rains, and the partial rainy season of winter, are extended up the valley of the Mississippi for a considerable distance, and so much as to induce the impression that there is an atmospheric eddy or basin here, in which general circulation ceases, and the conditions most favorable to accumulation of moisture and to profuse precipitation are found. The question presented by this constant concentration of the areas of maximum precipitation in the basin of the lower Mississippi are worthy a more thorough analysis than can now be made.

Passing to the districts of most profuse winter rain on the Pacific coast, we find the European analogies fully sustained, and results quite similar to those of the west coasts of the British islands and Norway. For the lower latitudes, or in California, the humid atmosphere has considerable elevation, and the rains are not wholly arrested by the lofty chain of the Sierra Nevada, and at the same time they are not extraordinarily profuse at and near the level of the sea. In Oregon they are more low and local, falling very profusely at sea level and on the low coast ranges. No very large quantity remains to be arrested by the range of Rocky mountains, though these are so high as to nearly exhaust the moisture not deposited near the coast, and to receive a large quantity of snow in the whole course of the cold season. At Astoria the quantity of winter rain is much like that of Bergen, in Norway, which at 60° north latitude has a mean of 23.5 inches of rain in winter for a period of ten years. Points of the west coast of Ireland, and of Scotland and parts of England, would not differ largely from these measures. Bergen is considered as the most extremely rainy of European positions in its winter climate, and it is probable that the quantity placed on the chart for our immediate western coast —thirty inches—is too great to be sustained by the results of a period of years. At Sitka the mean of seven years is 23.8 inches, and at Steilacoom that of six years is 22.6. The mean for the most exposed points of the coast cannot be less than 28 inches, and this quantity probably belongs to the whole coast, at least as far as Sitka.

In Norway the existence of abrupt mountains near the coast renders the comparison of interior districts similar, and a dry, cold, and unproductive region exists there like much of British America; but in other parts of Europe the humid atmosphere of the coasts reaches far inland, adding largely to the winter precipitation, and softening the climate in regard to temperature in a corresponding degree. None of the Pacific districts afford these advantages here, and thus at all seasons the interior districts of Oregon, with those of the plains of the Columbia, of the Great Basin, and of California, are found to be characterized by like conditions of aridity, and by similar extremes and transitions of temperature. All this chain of basins and plateaus is alike in this respect, and its great area and peculiar position requires a considerable extension of posts of observation to define its climate with the requisite precision for all the purposes of occupation and transit.

The precipitation of the great Rocky mountain ranges in winter can only be stated with a remote approximation. It does not appear that the snows are remarkable for profusion at this season, and the great accumulations found by those who have attempted to traverse the mountains in any part of the cold season do not necessarily imply very deep falls in winter for the general surface. As all the precipitation from October to the close of May is retained on the mountains in the form of snow, the floods of June would be as large if the quantity were quite moderate in each month, and the general systems of drainage are not adequate to carry off the measure of rain and snow which falls on the mountains of the New England States. Assuming for the Rocky mountain region a winter precipitation equivalent to five inches in depth of rain, the rule of reduction of snow to water applicable in cold climates, of one inch of water to twelve of snow, would give sixty inches of snow for the winter fall. As most of the precipitation of spring and autumn is also in snow, we may suppose an equal quantity in spring and half this depth in autumn—the whole giving twelve and a half feet of loose snow as falling in the cold season on the higher ranges. The quantity can scarcely be greater than this anywhere, and its average is probably very much less.

The measurement of snows in their depth when first fallen has, unfortunately, received little attention in these military records, while attention to the melting of the quantity and its measurement as water has been, on the whole, very accurately and carefully given. The practical value of a comparison of the mean quantities of loose snow is now very great, since general routes of transit must be controlled by such considerations in forming connections with the Pacific States.

As a pendant to the general notices of the quantity of water falling in the winter months some distinctions should be made in regard to the proportion falling in the form of snow. This varies greatly in successive years for all parts of the United States, and very largely where it forms a regular covering of considerable depth during the winter. It is difficult to construct useful averages for this reason, and also because so little attention has been given the point. It has been accurately observed in but few instances, and these mainly by persistent and careful amateur observers. In another place the general features of contrast between America and Europe in regard to the quantity of snow and its persistence as a covering for the ground in winter have been noticed, and it would be desirable to give some statistics here if they were accessible. But the New York system of meteorological observation affords few records of the kind required, and few are found in the observations at the military posts.

The quantity of snow is always large in the New England States, the elevated and northern districts having an average of perhaps two feet constantly remaining on the ground in winter. In northern New York it is the same, and as much or more is found in Canada at all points north of Lake Ontario. In the elevated portions of southern and eastern New York the average persistent quantity does dot reach a foot in depth, except on mountains. In the basin of Lake Ontario, as it is sometimes called,—the lower portion, to which Auburn and Rochester are central,—there is no regular quantity on the ground in winter, and for half the time, on an average, none remaining. But here and in Southern New York there is great inequality,—sometimes a winter occurring with very little, and at others immense quantities falling and remaining for several weeks. In extreme cases, of which the winter of 1855–6 was perhaps the most conspicuous, from three to five feet in depth have fallen at one time over this basin or low plain, and still more on the highlands east and south. The winter snows are often excessive from Buffalo eastward, and they are much more likely to be so than at points west of Lake Erie. In the Lake Superior region there are snows which may be called profuse in comparison with those of the plains, yet none equal to the extremes in New York. The southern part of the lake district—including the south end of Lake Michigan, the State of Michigan in the latitude of Detroit, and the whole country bordering Lake Erie on the south—is one in which the winter snows melt almost immediately as they fall, and very rarely lie on the ground as a winter covering. At Cincinnati the careful observations of Dr. Ray show an average of *nineteen* inches annually for sixteen years, most of this melting immediately after falling.

Farther west the quantity is less, and it is not more regular in remaining on the ground though the temperature is much lower. It is small over the upper plains of the Missouri and Saskatchawan, though usually affording a track for light sleds which may be driven any where without obstruction from its abundance. Some minor floods of the rivers of the plains are caused by the melting of the snows, but they are never equal to those caused by the rains of early summer.

Below or south of the 41st parallel the snows are extremely irregular, and yet often profuse and excessive. They are more likely to occur in February and the spring months as extraordinary phenomena than in the early part of the winter, and instances are frequent of profuse April snows. A few citations of the observed average depths of snow may be given here, taken from various published notices mainly.

Oxford co., Me.	12 years.	90 inches.	Hartford, Conn.	21 years.	43 inches.
Dover, N. H.	10 "	68.6 "	Lambertville, N. J.	8 "	25.5 "
Montreal	10 "	67 "	Cincinnati (Dr. Ray)	16 "	19 "
Burlington, Vt.	10 "	85 "	Burlington, Iowa	4 "	15.5 "
Worcester, Mass.	12 "	55 "	Beloit, Wisconsin	3 "	25 "
Amherst "	7 "	54 "			

At Burlington, Vermont, Prof. Thompson's observations give 24.8 inches for December, 14.8 for January, 17.6 for February and 16.9 for March.

The average number of days on which snow fell at Radcliffe Observatory, Oxford, England, for 25 years previous to 1854, was *ten and twelve-hundredths* (10.12) yearly; the measured depth is not given.—*Radcliffe Obs.* 15*th vol.*

MEAN ANNUAL DISTRIBUTION OF PRECIPITATION.

The summary of the quantities for the several seasons in mean quantities for the year exhibits a more symmetrical distribution of precipitation than belongs to either of the first charts. The results are believed to be less liable to error from imperfection of periods, and from the great range of non-periodic variations, than in the case of periods embracing but a part of the year. This conclusion is based on the assumption that the non-periodic variations in the quantity of water falling in rain do not cover so much time, and that the compensating extremes are more likely to return within the year than to be deferred to subsequent years. It is, however, scarcely possible to decide this point from the existing records, as in several of the more complete series there are years known to possess constant errors of measurement, either in excess or in deficiency.

The general features of symmetry are, first, the great quantities in the lower Mississippi valley and the Gulf States; next, the comparatively large quantities and gradual out-shadings of other parts of the Mississippi valley; the uniform measures of the Atlantic coast throughout; and the uniform and decreasing quantities from this district to the higher districts of the whole Alleghany range, and still more to the lake district—which last is also quite uniform throughout. The falling off on the northern portion of the plains is quite abrupt, and not only the very complete series at Fort Snelling so far establishes this point, but such partial records as are obtainable from positions near that post, and the features universally ascribed to the vicinity of Fort Pierre, confirm it. The plains are quite symmetrical in their quantities beyond this point, so far as may be ascertained, and the valley of the lower Rio Grande appears to correspond very well, and to continue this symmetry of the yearly results. Beyond the plains the characteristic features of the districts of periodical rains are strikingly exhibited, and southern Florida gives strong evidence that it should be identified with the districts of periodical rains, rather than with the area of constant precipitation of the eastern United States. There are fewer irregularities in these annual summaries, however, than in the sums for separate seasons; and the possibility of making an illustration of sufficiently precise and practical value would not be doubted in regard to these quantities.

In comparing this illustration with the charts of Berghaus and Johnston, the deficiency on the coasts of the Atlantic and Gulf States is quite apparent. The gradations *increase* toward the interior, instead of *diminishing*, on any parallel from the Atlantic coast toward the Mississippi valley, at least as far north as 43° of latitude, and above this parallel there is but a slight extension of a district of greater precipitation on the Atlantic coast. From the Gulf coast northward there is also a decided increase at some points, and for a moderate distance; as also from the coast of St. Augustine (Fort Marion), Florida, northwestward toward the interior of Georgia. The Pacific coast has the analogies heretofore attributed to all temperate climates, but they are there greatly exaggerated in quantity for the northern, and diminished for the southern portions. The prominent deduction derived from this feature giving the greatest quantities in the interior for the eastern United States, and from the uniformity of the quantities over large districts and their extraordinary symmetry, is, that the supply of moisture for precipitation is from remote sources, and that the immediate inducing causes are not found in the configuration of the country. If the altitude of the hills and mountains of this part of the continent has any agency in inducing precipitation, we should find interruptions in the symmetry due to them, and an irregularity conforming to their irregularities of position. This would be more apparent if their effect were supposed to be to increase the quantities, as is generally the case elsewhere, than if they had a negative relation to them, or one tending to diminish the measures. The last is, in truth, to some extent the real relation of the districts having considerable altitude, if not of the sharper elevations and mountains themselves, to the quantity of water falling in the vicinity of the Alleghanies; though such a relation cannot be considered in the same sense as one of increased quantities, since it is merely an interruption of the uniformity which would appear if the whole were a plain.

By comparison of the hyetal with the thermal condition for this area, we see a similarity which may solve the questions indicated in the contrasts just noted. East of the plains the shadings conform to the curvatures of the thermal lines, and this in a striking manner, if we take the thermal chart for the summer, in which season the excesses principally fall. The higher temperatures then fall inland, even for all the southern coasts; and the great heats of the Mississippi valley, the recession of the lines about the lake district and about the Alleghany mountains, the heat of the interior of southern Florida, and many other points of correspondence, indicate clearly the existence of definite and necessary relations of these two conditions for the district under consideration. *The quantity of water precipitated in*

rain is proportioned to the temperature, and not to configuration or to proximity to the sea.

To this general principle there are partial exceptions, one of which has been mentioned in the extension of the heavy shading on the northern coast of New England. This district, including the highlands and mountains of most parts of the New England States and New York, has more rain than would fall to it by the general rule; and there is some evidence that the contact of atmospheric volumes with those altitudes induces a share of the precipitation, as in Europe and on the Pacific coast. The next exception is in the lower part of the lake district, the vicinity of Lake Ontario in New York. Here the temperature is highest, and the quantity of rain is least for its latitude, except, perhaps, the vicinity of Lake Michigan, on both sides. As the basin of Lake Ontario is some hundreds of feet below the greater part of the lake district, the exception is more apparent than it otherwise would be; and the absence of the greater quantities which should be found there, if the latitudes were lower, shows only that the northern limit of this distinctive district is nearly attained, and that it would not exclusively belong to latitudes as high as forty-five degrees. The profuse rains of the St. Lawrence valley and basin, however, still in a great measure confirm the general principle, and associate a large proportion of precipitation with its seasons of highest temperature. A more critical and thorough examination of the northeastern districts in their mutual relations at the various seasons is very desirable.

The district of the great lakes has a general feature of a character perhaps least to be anticipated, in showing a decided diminution of the quantity of precipitation in comparison with the districts of its vicinity. That these bodies of water should reduce the annual quantity of rain instead of adding to it may appear probable, yet in comparing the results exhibited on the chart for the year, it is demonstrable that they do so. Under the general principle just mentioned the explanation is more simple than might be expected, since it is dependent on the relative capacities of the local atmospheres to sustain moisture, the precipitation being more or less profuse accordingly. If at Cincinnati the mean temperature may be for some days at 85° and at Fort Gratiot but 60°, with a degree of humidity near saturation in both cases, a change of temperature which would precipitate *like proportions* of this moisture would give twice the depth of rain at the former place. Such, for nearly all parts of the year, are the relative thermal conditions for the atmosphere of this immense cool water surface and that of the Ohio and Mississippi valleys, and the hyetal conditions are only similarly contrasted.

If the quantity of water precipitated at all seasons depended on

local sources of supply in the evaporation from ocean or lake surfaces, there should be, notwithstanding the rule just mentioned, a considerable increase on the hills in the vicinity of the lakes in winter or the colder seasons. There is, undoubtedly, a partial or small increase of this sort, which is most conspicuous in New York and in the vicinity of Lake Superior. But the amount so added is due to the greater temperature of the lakes at this season, and to their slower cooling, as their local atmosphere retains a degree of humidity and a capacity for moisture which does not belong to the atmosphere of the land areas in their vicinity. The quantity is also not very great, and it is more conspicuous at the cold season, than important in its addition to the quantity for the year. The number of days of rain and snow is also increased disproportionately to the actual quantity. Near Lake Superior there is, apparently, a heavier fall of snow in winter than elsewhere, or perhaps this profusion belongs to all the hills and low mountains surrounding this great lake. The great plains begin at this western limit, and they stretch northwestward to the Saskatchawan and beyond it; the whole country to the Rocky mountains, indeed, being a single low and unbroken plain. Whatever influence moderate elevations would have in this latitude and position in inducing a heavier fall of rain and snow might be anticipated here, and there may be a relatively large quantity so derived. This does not affect the general feature of the lake district which has been examined, as nearly all the country in the vicinity of the other lakes is a plain very little elevated above them.

There is an exceptional district having a great fall of rain in Iowa, which requires some explanation, especially in its contrast with the small quantities at Lake Michigan. In Iowa and northern Missouri there is a district lower than these the adjacent States, which has a high temperature, and which may be designated as a sort of atmospheric eddy, similar to that of the lower Mississippi. In the northwest of Iowa, again, the *coteau* formation appears in its most perfect development, and there are decided features of this sort in central Wisconsin. On these, and on the shore of Lake Michigan, the quantity falls off abruptly, in a manner strikingly like the curvatures of the thermal lines. The influence of the plains is thus apparently extended eastward at St. Louis, reducing the quantity elsewhere belonging to the Mississippi valley from fifty to forty-five inches in the mean for the year, though the belt so reduced is comparatively narrow, and it does not reach to the southern line of Missouri.

Another instance of the intrusion of the influence of the plains appears at Fort Snelling, and the principles are the same as in the case just examined. The district is more extensive, however, belong-

ing to the whole *coteau* region of the Mississippi and Missouri. The reduction in quantity is very great, and further west the measure diminishes still more. There are no sufficient measurements for this district, however, and only local descriptions and analogies are relied upon in carrying the illustration beyond the observed points at the military posts. The remark is usually made of these prairie reaches, from Fort Pierre to Fort Union, *that they are uncultivable from the absence of summer rain.* It is observed, in an equally decided manner, that the winter rains and snows are of very small amount, and it is clear that with these large deficiencies in the extreme seasons the sum for the year cannot be large. There are some partial records at Fort Benton and Fort Pierre* which support this view, and which give, with estimates for some partially omitted months, the measures used in the illustration.

Below this great arid area of the plains there are localities of more abundant rains, which stretch out on the highlands of Missouri first, and which subsequently come near the Canadian river. Its largest measure is on the Wichita and other mountains of the vicinity of the Canadian river, and at this latitude it approaches the spurs of the Rocky mountains, in their extension eastward from Santa Fé. The positive measurements at Fort Riley and Fort Atkinson, with those at Fort Arbuckle, Las Vegas, and Fort Union, are the only data for this district yet procured.

In northern Texas another particularly dry plain throws the shadings eastward, but south of this the rougher elevations and low mountains have a larger fall of rain, which belongs in some degree to the mountains farther up the Rio Grande. The lower valley of the Rio Grande is again extremely dry, except just on the coast of the Gulf, and southward from this point it is only known that the rains are much more profuse until the high interior of Mexico is attained. The last dry district named is, therefore, the most southern point to which this deficiency falls for districts having the general elevation of the United States.

As the large measures of rain for the eastern United States appear to be so directly associated with the temperature, the explanation of the diminution on the immediate coasts is not difficult. On the summer thermal chart the line of 80° is seen to follow the Gulf coast throughout, while 82° and 85° appear at large areas of the interior. The temperature does not rise so high within reach of the sea breezes, nor is the degree or fraction of saturation so great. By those who are familiar with the climate of the coasts this has long been under-

* Report of Survey of Northern Pacific Railroad Route, by Governor Stevens.

stood, and the removal of troops to the most exposed coast positions, to avoid the unhealthiness of the high temperature and more excessive saturation of partially interior posts, has been practised for many years. The rains are less profuse for even slight differences of this sort, and we need look no farther for the explanation of the differences of the records. On the south Atlantic coast this result is perhaps more marked than elsewhere, though the record at St. Augustine is not relied upon as entirely accurate. But the contrast of Charleston and Savannah, and that of Sea islands near Savannah with the city itself, afford decisive comparisons.* Farther north the exposed coast positions show a diminution evidently due to this local cause, and the farther these are at sea, or the more fully exposed to such influences, the greater is the difference of measurements disclosed. Near the Gulf stream the conditions may be reversed, however, as the temperature is considerably greater there.

In Florida the illustration for the year must be taken as in some degree hypothetical. At Key West the quantity is certainly comparatively small, though the records there differ very much from different sources and for different years.† But in the interior of the lower part of the peninsula the local rains are most excessive, and the local humidity and high temperature sufficiently extreme to render the measurement of the large quantities, or the fact of their existence there, free from doubt. Posts on opposite coasts of the peninsula usually agree in the cases of greater profusion. The non-periodic range is, however, very great for every portion of Florida, and more complete periods are required to give reliable measures.

The annual mean results, in the districts of periodical rains, have less interest and importance as such, than in those where the whole year is similar, or is a period of continued precipitation. The interest belongs to the seasons in the first case, and not so much, perhaps, to the recognized or standard divisions as such, as to the wet and dry seasons of these districts, whatever periods of time they may embrace. There is a great area very deficient in atmospheric precipitation, which stretches from the Rocky mountains to the great coast ranges, and from the point where the two ranges merge in one in British America,

* See the tables for Whitemarsh Island, Savannah, and Sparta, Ga.; for Camden, S. C., &c.

† An undoubtedly reliable record by W. A. Whitehead, esq., gives nearly thirty-two inches for a mean of fourteen years, though some part of this period was taken from other sources. The record at the military post differs largely from this, and in part this difference is due to greater profusion of rains, yet the result may not be wholly relied upon. A mean of these, or thirty-six inches, is thought to be near the average which an extended period would give, and this is confirmed by partial results on other islands.

south to near the latitude of the city of Mexico. Though both these great mountain systems are broken down in the vicinity of the 32d parallel, they rise again in Mexico, the coast range at the east arresting the tropical rains from one ocean, and that at the west from the other. Within the limits of the United States this great arid region may be said to embrace ten degrees of longitude and seventeen of latitude, drained only by the Columbia and Great Colorado rivers in any outlet to the sea. Fully half of it is the Great Basin of the interior, which does not receive a sufficient quantity of rain to require any external drainage. Taking this basin at nearly eight degrees of latitude by seven of longitude, we have two hundred thousand square miles so deficient in rain as to send out no rivers, and to accumulate no considerable lakes; and this statement places the contrast with the eastern United States in the clearest light. The two great rivers of the whole arid district receive most of their volume from the mountains themselves, and beyond its proper limits, and their basins might appropriately be added to the calculation, making nearly four hundred thousand square miles of surface, which, of itself, would send no rivers to the sea. In the division of river or hydrographic systems this deserves a distinct place, and its basis is in the permanent hyetal condition, which cannot here be wholly dependent on altitude and configuration.

The summary for the Pacific coast presents no features not apparent, in some degree, in the summaries for the seasons. It is to be regretted that the period of time is not longer for the upper part of this coast, and that the facilities for connecting the illustration still further northward are not at hand. Beyond Astoria and Steilacoom we have seven years of observation at Sitka, from Russian authorities, with a mean of 89.9 inches for the year. Without much probability of error we may suppose the quantity at Astoria continued, with a less rapid increase than before reaching this point, to Sitka, and the whole of this immediate coast to be marked by great profusion. Richardson notices its extreme humidity, and considers its degree greater than that of the most humid coasts of the British islands.

Distribution of Rain in New York, the New England States, and Canada.

The great number of observations at the New York Academies and Colleges renders the examination of the general district northeast of a line from Philadelphia to Lake Erie comparatively easy, and as this district differs essentially from most other parts of the eastern United States, it is fortunate that this accumulation of observations exists. There is less uniformity of surface here than farther west or south, and the interior valleys for the first time show a correspondence, in some degree, with European

distribution, and have less rain than the hills or elevated lands. These valleys are principally those of the Connecticut and Hudson rivers, Lake Champlain, the St. Lawrence river valley and the basin of Lake Ontario. There are many other minor valleys, particularly in New York, where an important falling off in the quantity of rain occurs; but these, with the narrow valley of the Connecticut river, cannot be distinguished on a general chart, though they modify the results by rendering it necessary to take the general mean between high and low positions.

The observations in New York are so complete and so numerous as to establish all the important facts beyond serious doubt, and taking these in three divisions,—those near the sea, those in interior valleys, and those representing the elevated portion of the State, which stretches from near Lake Erie at the south over nearly all the southern, central and northern counties, we have the following results. In the maritime district, including West Point, there are three military posts and five academies at which an aggregate of one hundred and forty-five years of observation has been made; the corrected annual quantity of rain being very nearly forty-two inches. West Point gives a larger quantity, and there is reason to believe that the first altitudes of the highlands have nearly forty-five inches. The next is the elevated portion of the State, including Albany. In this, thirteen Academies, with an aggregate of 177 years of observation between 1820 and 1850, give a corrected average of nearly thirty-nine inches, and as these points of observation are in most cases in valleys more or less below the general level of the country it would be safe to assign forty inches as the average quantity for the district, inclusive of its valleys, and inclusive of the Mohawk and Susquehanna river valleys.

The great valleys of the State form the last division, and several separate averages must be taken. That of the Hudson river, which may be extended to embrace that of Lake Champlain, eleven academies and colleges, and two military posts, with an aggregate period of observation between 1825 and 1855 of 185 years, gives quite uniformly, for partial averages and for the whole, thirty-six inches as the annual quantity. This is a falling off of at least four inches from the country in the vicinity on either side. The same quantity also belongs to the level of Lake Erie, represented by Fredonia and Buffalo, and stretching over a considerable space about the heads of the interior small lakes, where the country is first considerably elevated above the basin of Lake Ontario. In this basin, or but slightly elevated above it, there is a considerable number of observed points. Twelve academies and colleges with an aggregate of 142 years of observation between 1825 and 1850, and three military posts with an aggregate of 25 years, give, both for partial averages and for the whole, very accurately thirty-two inches as the annual quantity. One station, at Lewiston, gives much less, or but 22 inches, but it is probably to some extent erroneously measured.

For another portion of the great valleys, that of the St. Lawrence, we have a still smaller quantity,—five academies giving, from observations for forty-three years, but twenty-nine inches of rain.* This proves that in the deep interior valleys

* The summaries here referred to may be given in a note in this place, though the general results appear elsewhere with the collected statistics.

In the first or Maritime region, we have the following stations:

Clinton Academy, E. Hampton, Long Island	16 years,	38.60 inches Rain.
Union Hall Ac., Jamaica, "	25 "	39.05 "
Erasmus Hall Ac., Flatbush, "	26 "	43.00 "
New York Inst. Deaf and Dumb, New York City . .	3 "	46.26 "
Fort Hamilton, N. Y. Harbor	14 "	43 65 "
Fort Columbus, "	19 "	42.23 "
North Salem Acad'y, Westchester Co.	18 "	42.41 "
Mount Pleasant Acad. "	12 "	36.19 "
West Point Military Acad'y	12 "	46.53 "

at this latitude the quantity of rain is much diminished, though some doubt rests on the accuracy of this last result. The few observations at Montreal and Quebec show at least thirty-six inches at these points, and it is believed that the quantity increases in the lower or northern part of the valley. At Toronto Observatory the record has been kept for fifteen full years with an average of 31½ inches, but it is not clear whether the quantity falling as snow has always been included.

There is a point of distribution apparent at one of the stations on Long Island, which, as confirmed by several other records in that vicinity, makes a decrease in quantity towards the sea from New York, falling from 42 inches at that point, to 39 inches at the eastern extremity of the island. With this in view we find the greatest quantity for the State of New York near the Highlands of the Hudson, and a diminution from this line both towards the sea and inland. In this last direction there is little change from the quantity of forty inches except in the valleys and lake basins, all of which are more or less diminished, down to the minimum of 29 inches in the St. Lawrence valley. The topography and configuration influence the results very much and also differently from the action of the same causes in Virginia and the south. The highlands have more in every part of New York than the valleys or plains of their vicinity, which, as a rule for a large district, is hardly the case on any other part of the Alleghanies southward.

In the second or elevated district; average 39 to 40 inches:

Delaware Ac.	2 yrs.	41.88 In.	Hartwick Ac.	14 yrs.	37.88 In.
Cherry Valley Ac.	14 "	41.14 "	Fairfield Ac.	17 "	36.60 "
Oneida Conf. Ac.	19 "	38.30 "	Johnstown Ac.	14 "	39.82 "
Hamilton Coll.	18 "	34.52 "	Schenectady Ac.	2 "	40.68 "
Utica Ac.	19 "	40.68 "	Cambridge Ac.	13 "	40.14 "
Oxford Ac.	17 "	36.05 "	Albany Ac.	24 "	40.93 "
Bridgewater Ac.	4 "	44.02 "			

At Albany the high lands approach so nearly as to identify it with the elevated district rather than with the Hudson River valley, and the results of its long and accurate record confirm this classification.

In the Hudson and Champlain valleys; average 36 inches:

Newburgh Ac.	18 yrs.	35.58 In.	Watervliet Arsenal	19 yrs.	34.55 In.
Poughkeepsie Ac.	14 "	38.13 "	Lansingburg Ac.	20 "	33.47 "
Kingston Ac.	19 "	37.53 "	Granville Ac.	14 "	31.69 "
Redhook Ac.	10 "	34.73 "	Washington Ac.	7 "	32.83 "
Hudson Ac.	16 "	35.96 "	Burlington Coll., Vt.	18 "	33.90 "
Kinderhook Ac.	17 "	35.81 "	Plattsburgh Ac.	3 "	38.09 "
			Plattsburgh, Fort	10 "	33.39 "

In the west of New York;

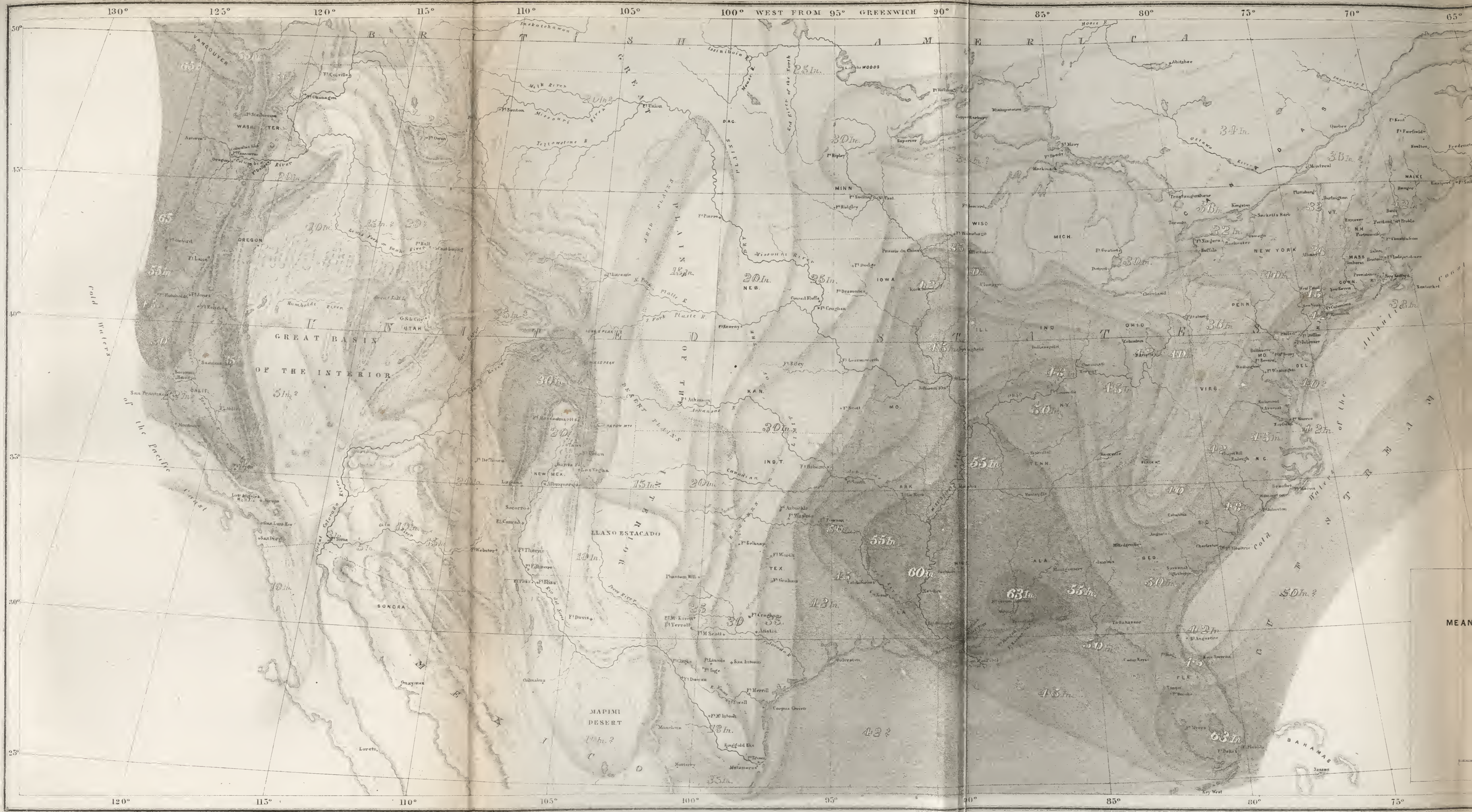
Fredonia Ac.	16 yrs.	36.68 In.
Springville Ac.	2 "	37 44 "
Buffalo, Fort	4 "	38.80 "

In the basin of Lake Ontario; average 32 inches:

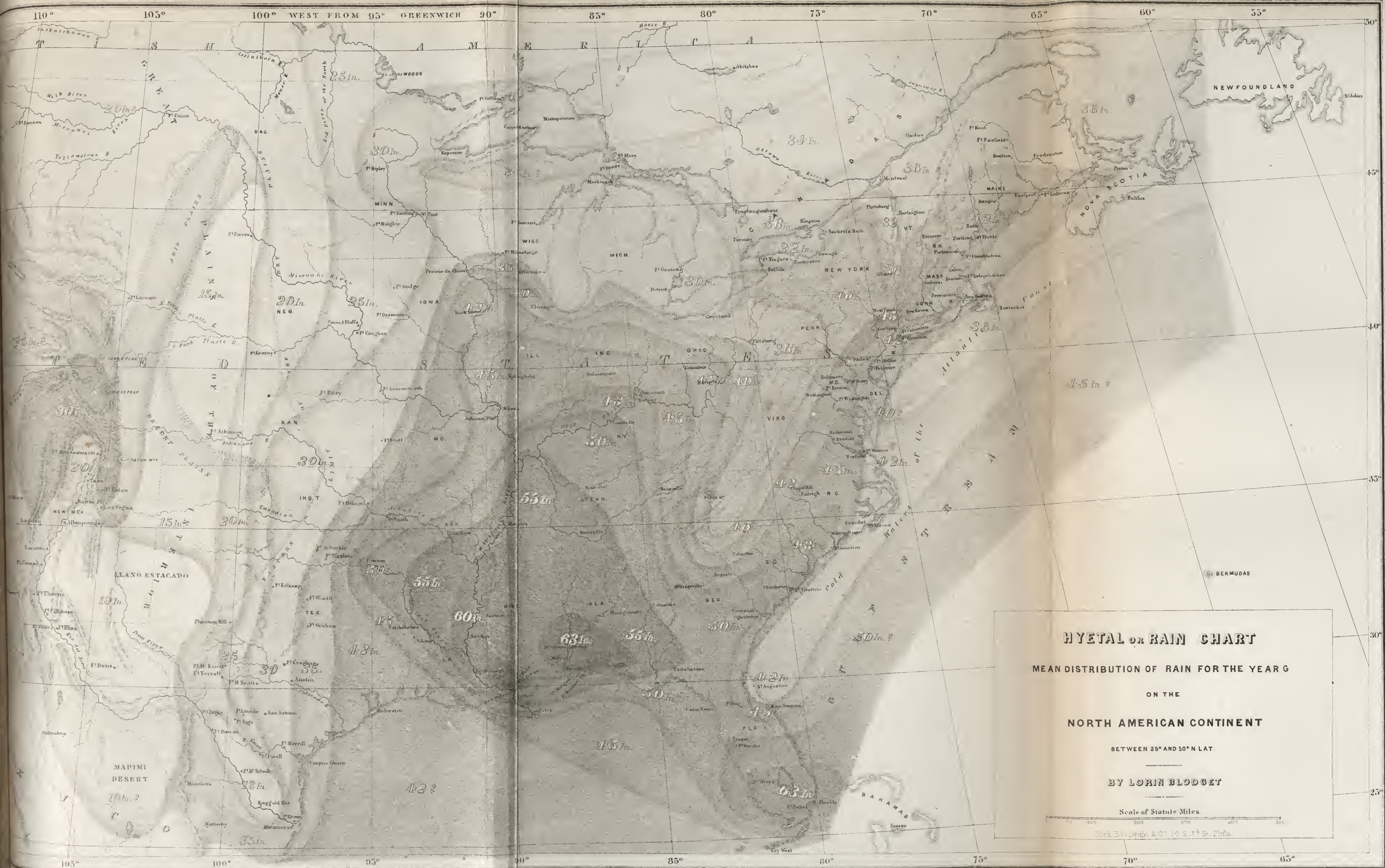
Toronto Observatory	15 yrs.	31.47 In.	Auburn Ac.	22 yrs.	34.52 In.
Fort Niagara	11 "	31.77 "	Cayuga Ac.	7 "	33.10 "
Middlebury Ac.	17 "	30.47 "	Sackett's Harb., Fort	6 "	33.00 "
Milville Ac.	6 "	28.94 "	Ithaca Ac.	13 "	30.39 "
Gaines Ac.	4 "	33.50 "	Onondaga Ac.	16 "	31.39 "
Rochester Univ'y	19 "	30.40 "	Pompey Ac.	15 "	29.46 "
Monroe Ac.	2 "	26.64 "	Mexico Ac.	11 "	30.78 "
Canandaigua Ac.	10 "	37.15 "	Fort Ontario (Oswego)	7 "	30.88 "

In the St. Lawrence valley; average 29 inches:

Bellville Ac.	9 yrs.	29.55 In.	St. Lawrence Ac.	20 yrs.	28.62 In.
Gouverneur Ac.	9 "	27.61 "	Malone Ac.	3 "	29.07 "
Ogdensburg Ac.	1 "	24.61 "			



130° 125° 120° 115° 110° 105° 100° WEST FROM 95° GREENWICH 90° 85° 80° 75° 70° 65°
B R I T I S H A M E R I C A
GREAT BASIN OF THE INTERIOR
LLANO ESTACADO
MAPIMI DESERT
SONORA
WASHINGTON
OREGON
CALIF.
UTAH
NEW MEX.
NEB.
KAN.
IND. T.
TEX.
MINN.
IOWA
MO.
ARK.
LA.
WISC.
MICH.
ILL.
IND.
OHIO
KY.
TENN.
ALA.
GEO.
FLA.
S. C.
N. C.
VIRG.
PENN.
NEW YORK
MAINE
VT.
MASS.
CONN.
DEL.
MD.
BAHAMAS
Cold Waters of the Pacific Coast
Cold Waters of the Atlantic Coast
GREAT PLAINS
DESERT PLAINS
MEAN
120° 115° 110° 105° 100° 95° 90° 85° 80° 75°



HYETAL OR RAIN CHART
MEAN DISTRIBUTION OF RAIN FOR THE YEAR G
ON THE
NORTH AMERICAN CONTINENT
BETWEEN 25° AND 50° N LAT.
BY LORIN BLODGET
Scale of Statute Miles
WEST FROM GREENWICH
NEWFOUNDLAND
NOVA SCOTIA
NEW YORK
MAINE
PENN
OHIO
IND
ILL
IOWA
WISC
MICH
MINN
NEB.
KAN.
MO
KY
TENN
VIRG
N C
S C
GEO
ALA
FLA
ARK
TEX.
IND. T.
NEW MEX
LLANO ESTACADO
MAPIMI DESERT
BERMUDAS
BAHAMAS
Cold Waters of the Atlantic Coast
GULF STREAM
GREAT AMERICAN DESERT PLAINS

XI. WINDS OF THE UNITED STATES, WITH EUROPEAN COMPARISONS.

It is believed that no department of climatological observation or deduction has been more greatly in error than that relating to the winds. The place assigned them has often been the first in the order of phenomena, or that belonging to an original agency and cause, while, when distinguished from the regular and constant atmospheric movements, which belong to various latitudes and localities, it is believed that they are the very last in the order of phenomena—wholly incidents and consequents, and never causes. As such they deserve much less attention than has heretofore been given them in observation, and in general deductions they might even be omitted entirely. With the distinction just named, or leaving out the movements originated by the distribution of temperature or other causes on the earth as a whole, they are merely the consequents of the changes of temperature and precipitation of moisture; acting as changes of density, and as the movement of bodies would act, to produce currents and movements in a mass of water. Without changes of density, and the intrusion and removal of bodies, there would be no local disturbance of the water.

In a fluid mass which is aeriform instead of a dense liquid, and which has constant changes going on in its lower half, and especially in its very lowest strata, of course the agitations are extreme in comparison with its other conditions, and local excesses of heat or moisture, with sudden removal of either, and the consequent change in the volume of certain strata, produce very violent winds and currents. But it is reversing the natural sequence and causation to attribute these changes to the winds,—to classify the barometric movements, the temperature, humidity, &c., after the winds, which are themselves clearly consequences of the changes of earlier conditions. To attribute this causation to *irregular* winds is neither more nor less than to assign intelligence and original action to them—to personify them after the manner of the Greeks and Pliny. As if we say the northeast wind *brings* a northeast storm with it, while generally and otherwise a west

wind prevails in the district where it occurs, or a northwest squall causes a thunder shower, when we find one—perhaps originating over our heads and with the northwest horizon clear—attended by a northwest squall; we are thrown upon the necessity of giving a reason why these winds come, bringing such incidents with them. In truth these winds *attend* them, and the causation is wholly in a different direction.

The winds of the temperate latitudes have been ably treated, both theoretically and by induction from observations, in recent works. Eminent authorities have receded from the hypothesis which assumes the existence of winds or atmospheric movements of cosmical character and origin, and have preferred to account for all winds by the unequal distribution of land surface and of heat in these latitudes. Com. Wilkes and Professor Dove have recently and very thoroughly elaborated this view, and each has expressed in decisive language his dissent from the view that there is a belt of prevalent westerly winds in the middle latitudes of the north temperate zone, which has its origin in a system of atmospheric circulation central at the equator, or at the equator of heat. Dove says: (Annalen der Physik, No. 94, 1855. *On the Distribution of Rain in the Temperate Zone*)

"It might seem paradoxical to say that the interior of Siberia has really such an absence of wind currents as we are in the habit of regarding as confined to the equator, but it must be declared a repudiation of physical laws to say that the air of the temperate zone continually moves around the earth like a steady west wind, as is now printed in every text book, for every one should know that the air moves only toward a region of disturbance, or after rising at such a place then turns back."*

Capt. Wilkes in a portion of the seventeenth volume of the reports of the U. S. Exploring Expedition, and in a reprint of this portion in 1856† with additions, states his general and entire dissent from the calorific theory, as it is called, of atmospheric circulation over the whole earth, and ascribes all the movements, general and local, to causes existing in the district affected. Both these authors regard all the winds as *incidents* of other conditions, and in rejecting a general system of atmospheric circulation, still more strongly than before insist upon the order of phenomena here claimed to be the natural one, and show the unsoundness of the great mass of observation and speculation in regard to this point, or based on this erroneous classification.

It is not proposed here to enter into the reasons for or against this theory of a general circulation of the atmosphere, central at the equator of heat, and ascribed to that as the chief agency; but a few of the

* Quoted from Dr. Rosengarten's translation in Am. Jour. Sci., Nov. 1855.

† *Theory of the Winds*, &c., by Capt. Chas. Wilkes; Philada. 1856 (in part from a paper read before the Amer. Scientific Association, August, 1855).

evidences that a *general circulation* exists in the temperate latitudes may be named.

The greatest fact of evidence, as well as the greatest practical point in relation to the subject involved here, is *the constancy of westerly winds in the middle latitudes.* At the 40th parallel as an average position, and on the isothermal line of 50° for the mean of the year as a central line, the evidences of this prevalence and constancy are overwhelming; and if, in the interior of the continents, there is a period or locality where they are interrupted, it is but an exception to a rule. In truth it appears that such interruption only occurs in the months of extreme heat or extreme cold, and then it is not known that the exception embraces more than the immediate surface air, leaving the upper strata, as is so often evident in the United States, to pursue a regular course from some westerly point.

In the Atlantic ocean where no disturbing land areas exist this west wind is strongest and most constant; so much so that at certain seasons sailing vessels cannot make the passage in a line from the British Islands to New York. The isothermal line which should control the precise direction of these winds, if the supposed cause be the true one, here runs northeasterly, and the prevalent winds have the same direction. Their resultant would be quite accurately along that line, and their strength and violence can be accounted for on no other hypothesis than that of a general movement of the atmosphere eastward. The simple facts for the Atlantic ocean alone, settle the question that other influences than those relating to land and sea simply, or than those which generate a sea breeze on a narrow coast and a monsoon on the border of a great continent, enter into the account as causes.

Then we have the same resultant from the west over all Europe corresponding to this thermal belt. It is so at the Black sea for most of the year, though in summer the conditions are anomalous. A recent volume of Russian observations (1853) has this remark:

"It is remarkable that at all the places bordering on the Black sea,—Catherinoslav, Taganrog, Simferopol and Nicolaieff,—the mean direction of the wind is from the *eastward*, while it is from the *westward* at all other places in European Russia. There is, however, an exception in summer at Taganrog and Catherinoslav, where the wind at that season prevails from the southwest."*

The peculiar desert districts south of the Black sea might be supposed to cause an anomaly on its shores, and though its storms are known to be from the westward, and similar to those of the Great Lakes of the United States, it is not surprising that the surface wind

* Russian Correspondence Meteorologique for 1851, p. xxx., St. Petersburgh, 1853.

should be a reacting one. The storms of the Caucasus, the humid, rainy eastern shore of the Black sea, and all those more general phenomena which express the facts in regard to the greater mass of the atmosphere, all concur to show its movement to be the same in the interior of the old continent, that it is here; that is, from the west as an expression of the general movement. The clouds so move, the barometric waves traced by Mr. W. R. Birt (British Assn. Reports) and others, and the humidity and rains are so distributed. Why should the thermal lines decline southward on the east side of continents if the atmospheric movements did not transfer refrigerated volumes of air, and why should opposite sides of the continent differ in temperature and humidity? The fact of a contrast in the opposite sides of one continent, and of a correspondence in the circumstances of contrast between the two continents is decisive, indeed, of some general movement and some general agency of this sort.

The west coast of North America is an intensified expression of this movement; it is nearly as apparent at Fort Laramie and other elevated points of the interior; and at the great Lakes it is undeniably the constant or resultant condition, disturbed by counter winds at the surface in many cases, but always showing itself in the general cause of clouds and storms.

Dr. Gibbons has noticed with great care at San Francisco the course of the higher strata of clouds—the cirrus and the very high stratus—when they were visible, and has found them to come uniformly from some westerly point, as he had also observed for many years at Philadelphia. The writer has long observed the same facts in western New York, where an average of not more than one instance annually occurs of clouds in the higher strata moving from any other than a westerly point. During three years of very careful registry directed to this particular point, but three instances of a contrary direction were observed; and these were during the prevalence of extensive and disastrous storms on the Atlantic coast. The lower clouds are from various points, and the wind is quite variable during the greater storms; two strata of different movement often lying beneath that from the west, yet the stratum from a westerly point usually deposits the rain, and when it ceases the rain fall ceases; though the lower strata may continue to run on the wind twenty-four hours or more longer.

The resultant at all observed stations whether estimated numerically or observed with accurate instruments of registry, is uniformly from some westerly point, and the average of positions from the 38th to the 45th parallel in the United States is from due west. Prof. Coffin has accumulated these observations at great labor, and has deduced

their resultant in several forms, all concurring to show that a strong and uniform westerly movement belongs to all the middle latitudes of the temperate zone, and one stronger indeed, at the east coast of the United States, than in the interior. If the cause of winds here lay wholly in the local contrasts of cool and heated surfaces, the reverse current, or one from the east, should prevail, for the summer, at least.

So far as this belt of westerly winds is concerned,—or more properly of atmospheric movement from the west, which may be felt as such winds or not according to local circumstances, even where the clouds of a moderately high stratum are steadily from the west,—it does not appear that any evidence could be stronger than that which has become an indisputable part of the general knowledge. It is cumulative on every hand, and it would weaken rather than confirm it to cite partial statistics. With the known direction that all storms, either general or local, take in the United States above the 35th parallel, it is superfluous to seek other evidence that the atmospheric movement is from the west in the general level of cloud formation. The showers and cumulous clouds of summer always have this movement, and with these, as with the general storms of winter, it is of no consequence what the course of the wind at the surface may be. Below the 35th parallel and on the Gulf coast only, do the showers of summer take a different movement, showing that the stratum occupied by the cumulus of average height does not there move from the west, but from the east or southeast—an inflection of the trade wind mingling with a local coast wind.

Another evidence, which appears decisive of this duplication of the aerial strata is found in the curve made by tropical hurricanes in both hemispheres. From their point of formation they drift with the atmospheric body westward toward the more humid seas, and on attaining a latitude of 25 degrees they commence to yield, apparently, to an influence deflecting them from above, or in the upper strata. At the 30th parallel they yield to it quite entirely, and above this they follow it along its thermal latitudes, as though they had risen so much as to enter the mass of air so moving, and by the movement of which they are entirely controlled afterward. It is difficult otherwise to explain the well established facts accumulated by Redfield, Reid, and others, in regard to the course of these storms.

There is next a proof that such a circulation exists derived from the quantity of rain deposited in the temperate latitudes, and particularly in portions of them which are obviously beyond the reach of direct sea air. The rains of the eastern United States fall mainly from the upper or westerly cloud in all cases. It is seen to be impos-

sible that it should be otherwise, when the phenomena attending it are considered. In illustration the common incidents may be cited; —a storm may begin at Buffalo, with wind and clouds from northeast or southeast, long before it is felt at Albany, and though the sky at the moment is so much obscured as to render it impossible to see an upper cloud, yet a careful observer would have seen such an upper cloud *preceding* the lower in formation, and from which the water must necessarily fall, since the lower clouds are but its incident and attendant. The storms may be exhausted at Buffalo before it is known at Albany or Boston, at which places the sky may be clear and the wind continue westerly. It is impossible that such a storm subsequently being transferred to Boston, should receive its principal supply of water from any other source than the mass of air moving from the west. The prevalent westerly winds must therefore be largely charged with vapor, and must exhibit a nearly constant precipitation either as clouds or rain.

In confirmation of this view we find all this belt of westerly winds to be a belt of *constant*, or *equally distributed rains.* Though changing place as the seasons change, the region of monsoons rarely or never comes within its limit, and there is no known district of periodical rains within it, except a very limited line on the Pacific coast of the United States, and in this the season of interruption is very short and the rains are extended into spring and autumn. The west winds of summer at San Francisco are an exception and anomaly, falling in the latitude of calms for the summer, because of the extreme contrasts of the temperature of the sea and the interior.

The fact that this belt is one of constant precipitation is strong if not decisive proof that it has a supply of moisture from some exterior source. In the wide belt of irregular winds and calms, and of trade winds which can have no such supply, the most extreme contrasts and irregularities exist, and it is everywhere characterized by *periodical rains.* Having no uniform supply analogous to that carried to the temperate climates by the returning equatorial current, it is only in the alternation of seasons and of positions that precipitation occurs.

Accepting this as the theoretical solution of the winds, or atmospheric movements, rather, of the temperate latitudes, the analysis of the observed results is easy. With these regular movements which find a general expression in the winds, there are to be found many irregularities and many instances of abnormal movements, monsoons, &c., as parts of the general effect produced by the positions of the continents, and their relation to the distribution of heat and to the seas. All the facts cited by Dove and Wilkes may be entirely consistent with the existence of the general movement from west to east, and

may be easily and simply engrafted on it, as independent in some measure of it. The winds attending great storms are but slightly modified, from the fact that they occur in a mass of air which carries the storm forward—eastward, always—four or five hundred miles per day; and similarly, the local movements produced by a heated interior district, or by any relation of such a district to the sea, may appear to be independent and primary phenomena, and when at their greatest development may seem to mask every other movement. In the winds attending a violent storm we may be conscious of little or no difference due to the fact that the whole phenomenon moves eastward. An east, southeast, west, or north wind may appear to us the same as if the whole did not move, as we know it does. All the monsoons and unusual winds cited by Dove as occurring in Asia and Europe, with the barometric changes originating them, may occur without necessarily supposing these winds from the west suspended or non-existent. The abnormal atmospheric movements in the lower latitudes here are more clearly independent than those on the eastern continent.

It is not necessary to infer the existence of conditions attending winds of *propulsion* for this belt of westerly winds. No such winds are now recognized anywhere indeed, and in these high latitudes a system of aspiration toward the equator may induce a system of returning aspiration, which finds its natural expression in these westerly winds. It is difficult to see that any greater conflict with physical laws is implied here than in the trade winds, and whether there be such conflict apparent or not, as we now understand causation, we have the facts to deal with, and cannot modify them.

In every form of numerical statement which may be given to the observations, the winds of the United States above the 35th parallel conform to the statements of direction just given, and a few citations from a class of statistics of a uniform character, the observations at the military posts, will sufficiently show the facts without accumulating statistics.

At Washington the observations of Rev. Mr. Little, in part published in the earlier military results, show an excess of westerly winds over all others combined, though local deflections place the larger numbers at N. W. and S. W.

For the northern and central States east of the Rocky Mountains the analysis of the prevalent winds has little interest, as the result is at present so well known, but it may be important to give some groups of results in support of the positions already taken. Though it would be of great scientific interest to give the exact rate of motion and force, the enumeration of days gives the same result in regard to direction. Taking the number of days, or one-fourth the number of actual observations from each point at all the military posts north of Fort Moultrie (Charleston, S. C.) for the year 1843, embracing twenty-five stations, we find the proportions as follows:

	25 Posts, North and East.	6 Posts, Southwest.	12 Posts, North and West.
	Days.	Days.	Days.
N.	26.7	35.3	25.
N. E.	40.4	56.	37.
E.	22.5	45.1	32.3
S. E.	30.	62.7	39.3
S.	33.1	42.3	39.2
S. W.	64.3	37.1	51.4
W.	47.2	11.3	43 5
N. W.	71.	35.7	71.5
Whole No.	335.2	325.5	339.3

The posts for that year occupied no part of Texas, but there is a large area above the latitude of Charleston which is evidently singular in its winds, and six posts there are combined for the averages of the second column. Near St. Louis the characteristic features of the Eastern States return again, and twelve posts are combined in the averages there. The numbers for the higher latitudes are very much alike, and it is clear that westerly winds largely predominate. The numbers for S. W. and N. W. are greater than those for west, it is true, but the resultant derived from all would vary little from west. Other points are very nearly equally balanced. But at the posts of Louisiana and Texas the predominating winds for the year differ largely, and are found to be from the southeast and southward, with but a low percentage of westerly winds. There is evidently much in the configuration of the locality, as at Fort Jesup nearly half the winds for the year are from the south, and a like proportion at Fort Gibson from the southeast. For the summer months the proportion is larger,—for June the southeast winds numbering 67 and all others 52, and for July 78 to all others 45. In August the preponderating point was east. Subsequent summaries will confirm this peculiarity.

Constructing a summary of the winds for this district north and east for the three years 1843 to 1845 we have a mean of 30.3 days at North, 41.9 at N. E., 22.2 at E., 31.5 S. E., 39.4 S., 65.3 S. W., 56.1 W., and 67.8 N. W. In these records the calms were often counted as winds of the character of the last observed, or that which fixed the position of the vane, and the summary makes up 354.5 days. Obtaining the resultant of these, as courses and distances, we have an equivalent of 77.8 days of west wind, all other points being neutralized ; or the resulting movement of the air is the same as that from 77.8 days of wind at half a degree north of west. This is a large measure of movement, and it establishes the general movement for these latitudes at true west beyond all question.

Professor Coffin has accumulated a mass of statistics quite sufficient to decide all questions that may be raised in regard to the general atmospheric movement in the eastern United States and in Europe. It cannot be necessary to go over the ground of his collections again, and though his observations were solely of the *number* of winds from any point observed, and do not include the element of *force*, they have a cumulative value from the association of a great number of stations, and from the long periods for which they are in most cases taken. By his charts the 35th parallel is the southern boundary of the regular westerly winds in the United States east of the 95th meridian, or for so much as he examined ; though in the immediate vicinity of the Mississippi the direction is considerably changed toward the southwest. This peculiarity will be examined in discussing the local winds of Texas.

Prof. Coffin gives his deductions as follows : "Passing out of this circle (of winds between the parallels of 60° and 66°) we find a zone or belt of westerly winds about $23\frac{1}{2}°$ in breadth entirely encircling the globe, and having the pole of its southern as well as its northern limit near the point before mentioned, viz, in lat. 84° north and long. 105° west. . . . Out of 251 stations in North America east of the Mississippi, and situated within this belt, all but six have the mean direction of the wind westerly, and these are mainly in districts characterized by strong local disturbances. Out of

the 245 stations at which the mean direction is westerly at all but *fourteen* it is at some point between S. W. and N. W.; and at 210 of them it is within 35° of due west, as may be seen by the following statement:

Within	5°	of due west	30	stations;	15	on the north side, and	24	on the south side.
"	10	"	70	"	33	"	37	"
"	15	"	100	"	45	"	55	"
"	20	"	132	"	60	"	72	"
"	25	"	159	"	70	"	80	"
"	30	"	186	"	80	"	106	"
"	35	"	210	"	90	"	120	"
"	40	"	222	"	96	"	126	"
"	45	"	231	"	100	"	131	"

"In all the 14 exceptions the rate of progress is small, and as a general fact, the farther the mean direction at any place deviates from the ordinary direction in the region where that place is situated, the less is the progressive motion."

"On the Atlantic ocean the mean direction of the wind in the zone we are considering is more southerly but more uniform than in the United States. Of the sixteen resultants all are westerly, and the entire range between them is but 51° 14′, or from N. 84° 20′ W. to S. 44° 26′ W."

"Out of 142 stations lying in this zone in Europe 117 have the mean direction from some point between N. W. and S. 30° W., and most of them are comprised within much narrower limits. There are but eight stations in Asia situated in the zone under consideration, and at all these the mean direction is westerly. . . In the Pacific ocean we have but one station, Iluluk, one of the Aleutian Islands, and there too the mean direction is westerly."

At Fort Laramie there is great irregularity in the results for separate years, and doubtless much error, yet the mean of five years gives 133 days of winds from S. W. to N. W. to 66 of easterly winds, 26 at N., and 7 at South. The traverse of these is nearly 20° north of west. For some of the observed years, particularly 1851 and 1854, the degree is nearly due west, and the proportion of westerly winds very much greater. It is unnecessary to traverse observations where they are known to be often wanting in accuracy, yet their general expression may still be very readily seized.

On and near the Pacific coast the posts at which winds have been observed are often under local influences which do not represent a general condition. Dr. Gibbons' observations at San Francisco, elsewhere referred to, particularly distinguish the local winds from the movement of the stratum of air bearing the principal body of clouds, and it is necessary to so distinguish the winds of nearly every district. The local winds, or the actual directions observed, will be examined as a class for the Pacific districts and their sheltered valleys.

Below this great belt of westerly winds which is assumed to belong to the temperate latitudes for 25° in width, and in the eastern United States lying between the 35th and 60th parallels, the whole distance to the tropics is occupied, on the land, by irregular winds, monsoons, calms, and winds definable only as *abnormal*—that is, as belonging to local and peculiar influences and not to systems. This is a district of great difficulty in examination. In addition to the natural effect of contrasted surfaces of land and water, producing land and sea breezes and limited coast monsoons, there are greater causes of irregularity to which the great monsoons are due, and the peculiar winds of Texas, the lower Mississippi valley, and California are of this character or origin.

In this belt the causes indicated by Dove and Wilkes are clearly applicable to the exclusion of others belonging to general or cosmical circulation, so far as the surface and sensible climate are concerned. This, however, is true of land surfaces only, since the trade winds are developed in it at sea. Every part of it requires some care in the analysis of its winds to render its climate intelligible, as some conditions change

abruptly from this cause. It is pre-eminently so in California and along the whole coast influenced by the cold winds of summer there. In Texas, also, the limit of the moist winds of the Gulf of Mexico, as brought by the constant aspiration inland in the warmer months, or from May to October, is the limit of humidity, and it marks the boundary of sensible precipitation in the form of clouds or dew at that season. It is asserted that these Gulf winds reach nearly or quite to the Gila river, also, passing over the long range of highlands and mountains southwest of the Rio Grande, to be dissipated, after moderate rains, in the intensely arid atmosphere of the Gila and Colorado river basins.

WINDS AND ATMOSPHERIC MOVEMENTS OF TEXAS.

On the coast of the Gulf of Mexico, throughout its whole extent, there is a great preponderance of winds toward the land, and these are in all cases more than *sea breezes*, as these are known in tropical climates. Westward of New Orleans they are much stronger and more nearly continuous than eastward, and on the coast of southwestern Texas they develop something very near a monsoon, as the term is used and understood in describing the climate of the eastern hemisphere. These winds have an important influence on the general climate of the Mississippi valley, and as surface winds they form a leading feature of the climate of the districts in which they occur, or in all the low country bordering the Gulf, particularly in Texas.

The records show that nearly all the posts in Texas participate in this preponderance of winds directed inland. Those in the valley of the lower Rio Grande,—Forts Brown, Ringgold Barracks, and McIntosh,—exhibit very remarkable results in their almost exclusive southeast winds from April to October, or during the whole period of the warm months. These winds are also stronger at the most distant of these posts from the sea, stronger at Fort McIntosh, than at Fort Brown or Corpus Christi, —which is proof that the impulse is not wholly at the coast, but that some adequate cause, at least for their continuation, exists far in the interior. From this most prominent district the frequency and strength of these south and southeast winds declines as the posts are more distant north and west. Those at the border of the first considerable elevation from the lower plains of Texas, as Forts Inge and Lincoln, San Antonio, Forts Graham, Croghan, Austin, &c., exhibit scarcely less of this effect than such as are on or near the coast. Forts Towson, Smith, and Gibson also show that this district extends to the valley of the Arkansas river, though there is much less of it in the immediate valley of the Mississippi. A southeasterly aspiration which is not an extension of the southeast wind of Texas, however, also exists at Fort Atkinson on the Arkansas, and at Fort Kearny on the Platte, but beyond this point it does not appear at any one of the military posts. There is no preponderance of these winds at Fort Scott or Fort Leavenworth, nor, apparently, at any point much beyond the posts named on the north and east. There is a marked prevalence of southwest winds at Fort Leavenworth in the warmer months, however.

At Las Vegas and Fort Union, where the high arid plateau borders on the mountains on the west, there is also no preponderance of southern or southeastern winds, they being much less frequent than north winds in fact, and there is none at any of the stations in New Mexico. From El Paso northward the winds at ports in New Mexico appear to be particularly local and variable, often blowing from all points through the day, and regularly so for months. The new posts between the Pecos river and the Rio Grande do not furnish observations in sufficient number as yet to determine whether the peculiar feature which is so conspicuous at Forts Duncan and Clarke is known beyond the Pecos or not. As the country is quite rough and mountainous near this river, it is probable that the tract between the Pecos and Santa Fé

resembles New Mexico more than Texas, and has winds of the most irregular and local character.

The line of direction of these southeasterly surface winds, it may be observed, leads to the most arid districts of this part of the United States, if prolonged from any of these observed points. In the summer months the Rio Grande valley is more arid at Laredo, Ft. McIntosh, than at the Gulf coast, and the whole upper interior of Texas is most remarkably deficient in rain in these months. This aridity seemed the great originating cause of this inland draft, indeed, which belongs to the district separating the dry and greatly rarefied atmosphere of the upper plains from the humid air of the Gulf. While the heat of these plains is as great or greater than that of the Gulf atmosphere this movement is naturally induced, and as the position of the Gulf in relation to the trade winds entering it, and to the smooth ascents of plain country over which these winds are carried, is particularly favorable to them, we find a measure of force in this coast or sea wind, and a uniformity much greater than any other district furnishes.

Dove and others have recently decided that all the great monsoons of the eastern continent are due to the interior rarefaction of land areas in the warm months, and the diminished atmospheric weight as shown by the barometer there proves this to be an adequate cause. If the great movements designated monsoons so originate there, it is not difficult to see that the rarefaction in our own interior areas may cause the moderate aspiration from the Gulf, and that this may be gradually deflected from a point near to east at the lower Rio Grande to southeast, south, southwest, and west successively, as the various latitudes of the upper plains are reached, blending at last with the great regular movement from the west.

The statistics of observation at the Military Posts of Texas strikingly establish the facts of this movement, and of its regular curvature over the plains until it is lost at the 42d to the 45th parallel. The following table shows the general expression of the Texan posts, which were then quite numerous along the entire border between the low and the high plains, forming a diagonal line many hundred miles in extent from northeast to southwest. Of the posts in the list four or five for each year were in the Rio Grande valley where the southeast monsoon for three months is perfectly defined. The averages give the expression for each year of the five, and for the mean.

Summary of Winds in Texas; in the mean number of days from each point derived from a group of Posts in each year.

	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.		Whole No.
1850. . .	27.	28 1	30.4	95 7	61.2	30.	12.	28.4	=	312.8
1851. . .	32.4	34.8	42.	93.2	66 5	27.4	12.5	20.	=	328.8
1852. . .	32.4	30.6	43.4	90.	61.5	25.5	18.7	26.	=	328.1
1853. . .	31.4	31.3	50.	104.2	57.	17.1	13.	23.1	=	327.1
1854. . .	29.8	26.	38.2	129.3	36.	19.1	8.4	28.6	=	315.4
Average .	30.6	30.2	40.8	102.5	58.4	23 8	12.9	25.4	=	324.6

Winds at Ft. Atkinson, Arkansas River; lat. 37° 47′, long. 100° 14′; Alt. 2330 ft.

	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.		Whole No.
Average for Spring, 3 yrs. 1851–3	25.1	14.2	12.1	19.2	17.6	10.3	6.0	6.6	=	111.1 days.
" Summer " "	4.8	10.2	11.3	31.4	25.1	11.2	5 1	4.3	=	103.4 "
" Autumn " "	20.8	13.8	5.2	18.3	20.7	9.6	9.5	9.3	=	107.2 "

For 1850 the averages are derived from 12 posts; Forts Worth, Graham, Gates, Croghan, Martin Scott, San Antonio, Fort Brown, Ringgold Barracks, McIntosh, Duncan, Inge, and Lincoln;—the last two for the last six months only.

For 1851 the same, and including Fort Arbuckle, Fort Belknap (six months), Austin

(nine months) Fort Merrill and Corpus Christi (also nine months each);—in all 17 posts.

For 1852, 17 posts,—the same, including Phantom Hill, and parts of the year at Forts Mason, McKavett, Terrett, Ewell, and Clark; omitting Gates, Austin, Martin Scott, San Antonio, and Corpus Christi.

For 1853, 14 posts, excluding four of the most northerly before named.

For 1854, 11 posts;—Belknap, Chadbourne, McKavett, Merrill, Ewell, Brown, Ring. Barracks, McIntosh, Inge, Duncan and Clark.

These results are strikingly similar for each year, and no doubt can exist that they are a true expression of the atmospheric movement for that great district. The resultant may be determined by a ready graphic traverse; it is at very nearly *true southeast*, with a mean number of days yearly equal to 114 of 324.6 observed, or 35 per cent. A similar grouping of posts from Fort Moultrie northward and Pittsburg eastward, embracing twenty-five for 1843, twenty-four for 1844, and fifteen for 1845 gives a resultant from nearly *due west* (N. 89° W.) of 77.8 days for 354.5 observed, or nearly 22 per cent.

Fort Atkinson on the Arkansas River, and in the midst of the great plains, is so important in its position that its results for three years have been given for the summary.

The southeast wind here tends toward south, and it is quite variable in its resultant for the various months and seasons. For spring it is light at northeast, nearly 17 per cent. of the observed winds. For May it is light southeast—south 45½° east at 28.7 per cent. of the observations. For summer it is south-southeast; S. 33° E. nearly, at 45.5 per cent. of the whole number. For autumn there is very little movement, but the observations give a very small measure from east-southeast.

At Fort Kearny, and at Fort Leavenworth the winds of summer become south-southwest. Farther north and east they change more rapidly, and are soon lost as the representatives of any general movement.

At Fort Union and Las Vegas, at the western border of the plains nothing of this resultant is found, there being, in fact, a reverse direction, or one from the northwest even for summer. The number of observations from points at the south and east is much less than at points in other quarters.

It is less easy to define the easterly boundaries of this district of south and southeast winds, because of the absence of observations along the Mississippi south of St. Louis. At Fort Jesup in Louisiana the winds from the south greatly predominate. At Fort Gibson a like excess of south and S. E. winds exists. The mean results of twelve years of observation, 1843 to 1854, give 78 days at S. E., 67.7 at S., 34.7 at S. W.; with but 12 at W., 33 at N. W. and 38.7 at N. of an aggregate of 327 days observed for the year. Taking the summer months alone the preponderance would be much greater at S. and S. E.

At Natchez the results of fifteen years of observation by Dr. Tooley, 1825 to 1839,* give the following results. The quantities are given in *days* for each, dividing the whole number of single observations by three, the numbers of daily observations, to obtain an equivalent in *days*. It is not therefore the separate or actual number of days on which such winds may have blown.

N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.
37	14	27	22	39	28	12	10

— "In this abstract," Dr. Tooley remarks, "it is shown that the southerly and easterly winds prevail over the northerly and westerly in the proportion of 100 of the former to 65 of the latter. The south winds are to the north winds as 100 to 95.8; the southwest to the northeast as 100 to 49.8; the southeast to northwest as 100 to

* Report of Regents of N. Y. University, 1841.

44.8; the east to the west as 100 to 43.7;—the southerly and easterly winds prevailing over northerly and westerly winds by a fraction over one-third."

At St. Louis Dr. Engelmann states the conditions as follows: "Southern and southeastern winds were, (in 1855) as is usually the case with us, the prevailing ones from April to October; in the other months western and northwestern winds have the preponderance. Most of the storms come from the west, northwest and southwest, and occur principally in the winter months. In summer we have fewer storms of wind, but besides the western sometimes southeastern ones, and often short, though occasionally violent thunderstorms from the west." "In 1851 the winds were as follows:

		N.	N. E.	E.	S. E.	S.	S. W.	W.	N.W.
Six colder months Nov. to April.	(Days.)	10	13	9	30	23	16	54	26
Six warm months May to Oct.	"	8	14	20	45	27	26	28	16

—— West and southeast winds are therefore the prevailing winds the whole year round and west more than southeast; the former more in the winter and spring and the latter in summer and fall."*

At Cincinnati the very careful observations of the late Dr. Ray are taken from his manuscripts for sixteen years, 1835 to 1850, with the following result:

	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W
Mean, 1835 to 1850.	23.7	34	24.2	11.3	18.4	80	95.2	55

Whole number of days, 341.8

These statistics are decisive that the southerly winds have ceased before reaching Cincinnati, and that they have become blended with the regular west winds of that latitude.

At Fort Snelling the proportion of days from each point for the year shows a complete institution of regular west winds, as at the eastern posts; the average numbers for 8 years being 219 at westerly points, S. W. to N. W., to 149 at all others.

In New Mexico and among the Rocky Mountains generally we come upon winds of the most extremely irregular character. It often changes several times in the same day, and at the four hours of observation of the military posts, each may be at a different point, and each recorded as a strong wind. There is also no regularity of direction at the successive hours, the phenomenon being controlled by local position relative to mountains, and by accidental occurrence of showers on the mountains, &c. There are no posts in positions to represent the rain-bearing winds, if there are such, and it can only be inferred from the observations that in the winter months the winds are westerly at the high points, as elsewhere in like latitudes. As Dr. Gibbons has shown that at San Francisco the high rain-bearing clouds are borne on a westerly current for all seasons it appears that the same is true of the higher latitudes of New Mexico at least,—and of all the country northward of the 35th parallel.

In summer, however, the rains of the mountains are so conspicuously local that it is difficult to say that they are borne from any quarter at this latitude. And below, or south of the Gila river, they are said to come with southeast winds, as an extension of the district of the summer rainy season of Mexico. At Fort Yuma on the Colorado river, these clouds from the southeast appear at the south and sometimes reach the post, but they are generally dissipated before going so far, though constantly moving on a current of air bearing them toward the most heated portion of the desert. As surface observation of these winds has been made, it is impossible to say to what extent the influence of the Mexican rainy season of summer should be recognized here.

At Fort Yuma, on the Colorado river, the fitful surface winds continue, with a predominance from the north and west. They are variable and often severe as "sand

* St. Louis Medical and Surgical Journal, July 1852 and March 1856.

storms," which appear to be similar to those of all sand deserts. There is no uniform direction of the wind in these cases, though they are oftenest from the south and southwest.

At the passes of the Sierra Nevada, and at all the entrances from the coast of the Pacific to the interior arid districts and deserts, there are violent and continuous westerly winds. In many places abrasion of the rocks is asserted to have been produced by the sands driven on these winds ; the rocks and clay surfaces become polished, with cavities and traces worn in parallel lines, like the abrasion of rocks caused by transportation of masses of rock or ice.* The effect of ages of this ceaseless draft from the cool atmosphere of the Pacific coast into the hot and rarefied basin of the desert through narrow passes, has undoubtedly produced marked effects, if not all those ascribed to this agency there.

In all the west of our temperate latitudes the extreme form of the conditions lying at the basis of the monsoons and winds of Asia is found, or the extreme single conditions which constitute the requisite contrast, are in the most immediate proximity. The desert area is less than in Asia, but it is nearer a cold sea. We have not yet been able to measure the absolute rarefaction of the interior, or the diminution of the weight of the air as shown by the barometer, as has been done in Asia.

On the Mexican coasts below California and in tropical latitudes the inward draft of air produced by interior rarefaction is decidedly developed. Capt. Wilkes designates this as the locality of the "Mexican Monsoon," blowing alternately up and down this coast, or northwest and southeast. "The duration of the northern monsoon is from the month of December to May ; the currents of air are from the northwest, and nearly parallel to the coast. They seek the heated waters of the Gulf and Bay of Panama. During its prevalence fine weather is experienced,—whence this season, although the winter of the northern hemisphere, has been denominated the summer of those regions. In the offing they blow with more strength and steadiness than near the land." . . . "When the sun advances to northern declination, heating the land of North America from the month of May to September, the currents of air are from the south and southwest. These are the stormy months, attended with great explosions of electricity, and with copious and constant precipitation, which is produced and evolved by evaporation and condensation."†

This interior rarefaction is sufficient to bring a *northwest* wind on the coast from perhaps the 42d to the 35th parallel, and a *south* or *southwest wind* for a long distance below the entrance to the Gulf of California—lines which if projected to the interior would cross nearly at right angles over the central areas of the dry interior. On the other side of the continent the southeast monsoon of Texas blows directly toward the northwest wind of California,—all proving how great and important this agency is in producing the surface winds of the latitudes below the well determined belt of westerly winds.

The corresponding movements of the Eastern Continent are on a gigantic scale, as all its physical phenomena are. The Chinese and the great Indian monsoons are due to these causes and contrasts alone—the rarefaction of desert areas of the interior in summer, and their refrigeration in winter, each contrasting with the great seas adjacent. The monsoons of the Levant and of northern Africa are also similar, and there is no part of this debatable ground on the old continent which has not some form of continuous wind at some season due to these causes. It is not surprising that the great extent of these monsoons, and the immense areas mainly influenced by this alternate heating and cooling, producing the most decided contrasts with the temperature of adjacent seas, should so much outrank the surface movements which are

* W. P. Blake, Esq., before Am. Assoc. for Advancement of Science, 1855.

† Wilkes' Theory of the Winds (p. 19), 1856.

claimed to originate in a central system, or to be due to such a system, as to afford strong reasons for rejecting that system as Dove has done. In Europe and Asia the position of the irregular winds is farther northward than here, and the whole Mediterranean coast has a system of minor monsoons. There are few positions along its shores not subject to peculiar winds, if they are not continuous, and so remarkable as to deserve especial designation and description. All these have been long known in history under definite names, and they have often been personified, and connected with absurd views of their origin and effects.

Admiral Smyth in his work on the Mediterranean has defined all these again, and they may be named here as illustrative of the characteristics of the belt of irregular winds. At the Straits of Gibraltar the winds are usually either west or east, blowing in or out of the comparatively narrow passage. The east wind is generally called the *Levanter*, and it is often destructive to shipping and has a chilly, raw, and disagreeable air. At Cadiz it is at east-southeast to south-southeast, and is called the *Solano*. "This wind is preceded by a peculiar haziness and clammy humidity, as if owing to diminished atmospheric electricity." (*Ante*, p. 247.) The true Levanter at the Straits is a day wind which "freshens as the sun rises and lulls as he declines, being generally at the maximum about noon."

On the Mediterranean shores from Cadiz to Genoa there are violent irregular gales, and some of comparatively uniform character. The *Mistral* from the Alps, a severe and chilling wind rushing into the warm atmosphere of the sea is a sample of the northerly gales common to all this coast at intervals. There are violent storms from a southerly quarter also. "In and around Sardinia the most prevalent winds are from west-northwest to north, and from the eastward, the proportion of days being for the first 210 and the latter 145; these may be termed the dry and the humid respectively. The prevalent *Maestrale*, or northwest breeze, brings in a long swell from seaward, and it acts with such violence over the Nurra districts that the trees exposed to it are bent nearly horizontal in the opposite direction, and so they grow. The south wind rarely occurs but as a stormy winter visitor." (Smyth.) The east winds are damp and disagreeable here, and the *Levanter* is a southeast wind, not unlike the sirocco of Sicily and Italy.

Sicily is said by Admiral Smyth to represent the average of the Mediterranean positions; the most prevalent are the northerly and westerly winds, those from east to south are heavy, loaded with mists, and accompanied by heavy thunder storms. Here are the Eolian Islands, the fabled residence of the god of winds, and Smyth asserts that the squalls and contrary winds of the various straits of the vicinity are really severe and peculiar. But it is clear that the importance attached to these was anciently greatly overrated, probably from the inability of vessels as then constructed to sustain themselves in storms. Here the *Sirocco*, or hot wind from the African deserts, is first fully developed. Smyth remarks that it is so much softened by its passage over the sea that it is milder on first reaching the Sicilian coast than after passing some distance farther over the land. "At its commencement the air is dense and hazy with long white clouds settling a little below the summits of the mountains, and at sea, floating above the horizon, in a direction parallel to it; it often terminates by an abrupt lull, which is succeeded by a northeast breeze. The thermometer does not, at first, experience any very sensible change, though it slowly rises with the continuance of the Sirocco to 90° and 95°, which last is the highest I have observed, though the feelings—which are certainly a very inaccurate measurer of actual heat—seem to indicate a much higher temperature. But the hygrometer shows increased atmospheric humidity, and the barometer gradually sinks to about 29.6 inches. This wind generally continues three or four days, during which period, such is its influence, that wine cannot be well fined, or meat effectually salted; oil paint laid on while it continues will not harden; and while from seeming dryness it rives unseasoned wood

and snaps harp strings, it makes metals oxidize more readily, mildews clothes, and renders everything clammy."

"This wind is peculiarly disagreeable at Palermo, though on the northwest of Sicily. Although inured to the heat of the East and West Indies, and of the sands of Arabia and Africa, I always felt, during a sirocco here, more incommoded by an oppressive dejection and lassitude than in those countries; and it matters little to the person so attacked whether the sensation is attributable to the immediate parching of the skin and the absorption of electricity, or to a positive increase of temperature. . . It is more frequent in the spring and autumn than in summer, and in winter possesses no disagreeable qualities except to invalids." Dove shows that this wind comes from the "Sea of the West Indies," and not primarily from the deserts.

There are various local winds along the whole northern coast particularly, and we cannot do better than follow Admiral Smyth in referring to them, whose personal service in that sea was unbroken from 1810 to 1824, and whose volume, published in 1854, embraced all subsequently acquired knowledge on these points.

Hot winds, and violent northerly blasts called *Boras*, alternate in the Adriatic very frequently in the stormy seasons. "A very hard summer *bora* which I experienced in Lissa harbor on the 13th of July, 1819, occasioned a heavy fall of the mercury from 30.15 inches to 29.77; it was preceded by the usual denseness near the horizon with a fresh southeast wind; and during the two preceding nights, though the weather was fine, there was much lightning in a vast cloud bank that had formed. On the third evening this bank spread over the sky to the zenith, and the coruscations became incessant, . . at one in the morning the wind suddenly veered from E. S. E. to N. N. E. with great fury—in about an hour its force was somewhat abated, rain fell in large drops, and for two days afterwards we had cool breezes from the north and clear weather." (Smyth.) This is a very clear parallel to the ordinary phenomena of northers on the Gulf of Mexico, and it proves their origin similar—probably in sudden precipitation of a densely saturated and highly heated mass of air over the sea and near the land. Smyth describes another at great length of greater severity—but similar—which occurred in August of the same year.

In the Ionian Sea the winds are described as mainly irregular and local. There are *typhoons* in that part of the Mediterranean, which will be referred to in another connection, and waterspouts, which are both similar to those of tropical seas but less violent. In the Archipelago and eastward the *Etesian* winds prevail from the northeast through the entire summer, and are considered constant for at least 40 days. They are day winds mainly, and, like those of the Pacific coast, due to rarefaction, or to the greater heat of the seas south, and of the African coast. They are usually dry and bracing, and differ extremely in this respect from the east winds west of the Adriatic. "The true *Etesiæ* (ἐτήσιαι αὖραι, i. e. *annual breezes*) commence about the middle of July; rising at 9 A. M. and continuing through the daytime only." (Smyth.)

"The northeast and northwest winds blowing almost constantly during the summer may be called the monsoons of the Levant, and to them the Grecian climate owes many of its advantages." The author regards all these as merely exaggerated land and sea breezes; though covered with a profusion of technical and descriptive terms, and the subject of greatly labored and imaginative description by the ancients, they do not seem to differ essentially from all these phenomena in the transition latitudes. Our author's descriptions have been introduced in comparing the Gulf of Mexico with the Mediterranean, and but few more citations may be made here.

He describes the ancient Tower of Winds, at Athens, as still in tolerable preservation in 1820,—an octangular marble edifice, originally surmounted by a movable brazen triton which pointed with a wand to the quarter whence the wind was blowing. "On the upper story of each side of the tower is excellently sculptured a large winged figure in relief; those which represent cold weather are mature old men full clothed and bearded, in a style which the Athenians chose to call Barbarian; and the

milder winds are personated by youthful figures more lightly clad. Above them their names appear in uncial characters; and they are divided below, by a cornicc, from large dials constructed and accommodated for each face, those for the verticals of the cardinal points being regular, and their intermediates declining. It appears truly admirable for its object as an indicator of weather and time to the Athenians, though, from its proximity to the Acropolis it was badly placed to permit the vanetriton to show the true line of all the winds, since it could not be free from eddies."

"Over the door appears *Schiron*, the representative of northwest winds; he is robust and bearded, with warm robes and boots, and though mostly a dry wind, to show that he occasionally brings rain he is scattering water from a vase. *Zephyros*, the soft and benign western breeze, is a lightly clad, bare legged youth, gliding slowly along with a pleasing countenance, and bearing flowers somewhat significant of Ζωὴν φέρω (*I bring life*) in allusion to his genial influence on gardens.

"*Boreas*, the impersonation of the fierce and piercing north wind, is a bearded old man, warmly clothed, but without a water-vase, and he is so much affected with the cold that he guards his nose and mouth with his mantle. *Kaïkias*, or the northeast wind, which in winter is the coldest in Attica, is represented as an elderly man spilling olives off a charger to denote his being unfavorable to the fruits of the earth, and especially to olives, in which the plain of Athens abounds. *Apeliotes*, the east wind, is a handsome youth bearing various fruits in his mantle, with a honey-comb and wheat-ears, in token of his being favorable to orchards, &c. *Eurus*, the southeast wind, so often accompanied by tempestuous weather, is represented as a morose old fellow nearly naked, the agitation of whose drapery implies occasional violence. *Libs* the southwest wind, and the *traversia* of the Piræus, a robust stern-looking man bearing the aplustre of a ship, which he seems to push before him. The Romans, who usually copied the Greeks, gave dusky pinions to *Libs*, in allusion to its changeful energies, being by turns hot, cold, dry, rainy and serene, insomuch that it was reckoned unfavorable for ships to sail from the Athenian ports while the wind hung in the southwest. *Notos*, the south wind, has a sickly aspect and clouded head, significant of unwholesome heat and dampness; and he is emptying a water jar, as the dispenser of heavy showers in sultry weather. On the whole these weather *influences* agree remarkably well with those of the same winds for our climate."

Of the Black Sea the same author says that during the summer north winds prevail, and south winds during spring and autumn. The hardest gales are almost invariably from the west, and the storms seldom last more than twelve hours without abatement. At Taganrog, on the shore of Azof, the east winds are often severe and "continuous for several weeks"—they have frequent gales from west, though but few winds of any degree from north and south. This is attributed to the mountains of Caucasus.

On the south of the Mediterranean we have the latitudes of the Gulf coast here more nearly than on the north, and though the deserts of Africa change the effect to some extent, and transfer the equator of heat some degrees, there are many conditions corresponding to American districts. On the coast of the delta of the Nile the rains of winter come with west and southwest gales, and do not end till March. The Arabs designate these winds the *Fathers of Rain*. "In March the hot southerly wind called *Khamsin* (*fifty*) commences, blowing two, three or four days successively. It derives the name from its supposed limit between Easter and the summer solstice. It is also called the Samûm (*in Turkish S'ammyelí*) that is, the poisonous wind, from its suffocating heat. This in the central African deserts is often fatal, but in Egypt and Barbary, though oppressive and troublesome from filling the air with columns of hot sand, they are not dangerous. I have indeed been inconvenienced by them, but never experienced any really ill effect. The heavy hazy weather continues till the sultry east winds about the beginning of June may be said to usher in the summer, when there is sometimes hardly a breath of air stirring in the daytime and not a cloud to be seen; but at night the *northers* set in, the surrounding air cools rapidly and the

dew falls densely. About the 24th of June west and northwest winds refresh the air, and they continue more or less till September with an atmosphere generally clear."

At Tunis and Algiers the phenomena are similar to those of Sicily though more moderate. The Sirocco is not so humid, and its heat, though greater, is not more oppressive. In Morocco the principal winds are westerly, and the climate very equable and healthy. Hot south winds sometimes occur, and storms similar to those of the French and Spanish coasts, though less severe.

With this review of the winds of the most interesting region of Europe we should be able to associate a similar review of that of the west coast, including the British Islands, but the materials for such an exhibit are much less readily available than in the case of the Mediterranean. It is less easy to combine such statistics as are at hand, though they appear to be uniformly from the west above the 48th parallel.

Over the mountains of Switzerland the winds are extremely irregular as at all places in the vicinity of the interior seas. But elevated points in Asia Minor, of which there are several, give strong and constant resultants from the west. We cannot give the local peculiarities of districts farther from this, and for Germany and central Europe indeed there seem to be few local deflections—the resultant is quite uniformly from the west.

The peculiar winds of the Gulf coast in the United States were before only noticed in regard to the southeast monsoon, which doubtless influences the climate greatly. The reverse wind, which is the storm wind of the whole coast, the "norther" in Texas, and something quite similar all along the coast to southern point of the peninsula of Florida is like the various violent northerly winds of the Mediterranean, and entitled to rank beyond the fitful north winds of summer storms in the higher latitudes. As in Europe the conditions preceding the northern are great heat and saturation in the atmosphere over the sea, with the occurrence of a storm by which this is precipitated. They are, it is believed also, winds of *aspiration* in all cases, and not winds of propulsion from the land areas. There is little evidence of the existence of any winds of propulsion, indeed, or such as might be supposed to rush down from a land district or a cold sea *without a change of equilibrium first occurring at the area toward which they blow.*

In a discussion of these phenomena undertaken on the first accumulation of observations at the Military Posts of that district in 1851, the writer could see no other conclusion derivable from the records of these storms than that here indicated. In some cases the northerly or interior position had a reverse wind while the "norther" was blowing along the coast line, though it afterward moved over the interior. "The Norther is thought to be entirely analogous to the northeast and southeast winds attending general storms in the United States at the north. As in their case, the movement is one of aspiration, and the cause moves in a reverse direction above, thus giving the appearance of a movement backward at the surface, or contrary to the wind itself. It is, therefore, as are the principal surface winds in the other storms alluded to, a secondary phenomenon in all respects, and but the incident or attendant of disturbances."* They are also said to begin earlier near Vera Cruz than at Tampico when the two points are embraced by a single storm. They disappear along the coast line south of the Gulf, apparently by being exhausted as in filling a partial vacuum before going so far.† Vessels off the northern coast of Yucatan have reported the "norther" with its clouds and commotion visible at the west and north, while at their point a light easterly aspiration continued to be felt.

* Proceedings of the American Association for the Advancement of Science, 1853.

† Squier, in his work on Central America has, however, referred to a sensible continuance of the north winds in some cases across the Isthmus of Tehuantepec, basing upon this fact, the existence of low and practicable passes there.

XII. GENERAL WINTER STORMS OF THE UNITED STATES; INCLUDING HURRICANES, &c.

The colder months in the United States, including May and September of the warmer months, precipitate most of the rain and snow which falls in what are called general storms; or in those which extend over a large district as rain or snow storms, and which affect a still larger area in some manner or degree with the attendant winds and other phenomena. Most of the rain falling before the middle of June in the latitude of Washington is in storms of two or three days' duration, and if the whole period of evident preparation and of subsequent disturbance belonging to the rain is included, the average would be nearly four days. A south or southeast wind, with high temperature and a palpable sense of preparation, usually begins the change; east and northeast winds follow next for a day or more, during which most of the rain falls, and west or northwest winds blow with unusual strength for two days following, restoring the equable and average weather for the month.

In the northern States a greater number of months is included in those of general rains, or rather they may occur in every month of summer, though they rarely do so. In the Gulf States the period of summer showers is more extended generally, though where the hurricanes of August and September occur, as they do in all the southern States bordering the Gulf and the Atlantic, the number of extended rains in the summer is more nearly equal to that in New York and New England. In the southwest, at a distance from the coasts, they are rare from the close of April to the middle of October; in the interior farther west they are equally rare, and on the Pacific coast they belong only to the rainy months. But on the Pacific the rains have little if any correspondence at any season with those east of the Rocky Mountains, and no allusion to them will be made here.

These general storms have been a subject of inexhaustible interest in all American meteorological research, and great labor has been expended on the various hypotheses in regard to their laws. Some of these laws, and particularly those relating to exterior features and general movements, may be regarded as very well determined; their

general phenomena have been so conspicuous and so frequent of recurrence that some conclusions of this sort could not fail to result from the most imperfect observation. It must be conceded, however, that the theory of causation and the primary laws are still obscure; and that all basis of prediction yet remains unknown, if we may suppose that all their laws must include such a basis. In the lake districts and along the Atlantic seaboard such prediction, if for a few hours only, would be of incalculable service to practical interests, when such a foreknowledge would give the degree of violence attending the storm. It is now easy to indicate the advance of one from Chicago to Buffalo, and from Buffalo to Boston; or from one and another of the cities along the Atlantic from Norfolk to Newfoundland, yet in each case the result of value probably fails, because the hour and degree of violence can rarely if ever be accurately indicated. This negative result in regard to the value of despatches sent forward in the line any storm is supposed to take, is the most definite point now reached, and we are able to say that it cannot be foretold what the direction of wind and its degree of violence may be, even for so much as two or three hours, with certainty. It is not probable that so close an approach to prediction will ever be attained, yet some very valuable notices of the progress of these disturbances across the country may now be sent, to serve in some cases, and these remarks are intended only to guard against a degree of practical reliance which may lead to great disappointments.

In the vicinity of the lakes there is a greater opportunity than elsewhere to profit by the knowledge we have of these facts of exterior appearances and general movement, and from Milwaukie to Detroit, Cleveland, and Buffalo, the communication is very direct, and the succession of events quite the same. The barometer here is of less use than at sea, though always of great value, because some of the short and violent gales are scarcely indicated by it. A violent northeast gale at Milwaukie is certain to be felt with some force a few hours later at Detroit, and one violent at Detroit is equally certain to be felt severely at Buffalo. Northwesterly gales may always be indicated in the line of the wind's direction, and they rarely fail to go to Buffalo from any point of the lakes westward. Northeast winds *recede eastward*—in short, all the phenomena travel eastwardly in all cases, at a rate not less than twenty miles an hour, and usually at thirty to forty in the season of high west winds, or in winter.

The barometer is still the great reliance for safety in the general winter storms of the United States in all latitudes, as it is at sea, and in tropical climates. A great and rapid fall is an almost infallible indication that a storm is to be felt at the point of observation, though

more than that cannot be known. The point from which it will be most severe, the quantity of rain precipitated, its duration, &c., all depend upon so many causes of variation and irregularity as to be wholly beyond prediction. The sensible forces and visible phenomena of the storm are never the whole of it, and they are rarely the greater or controlling features. Whatever the movements at the surface, no law of forces for the whole phenomenon can be deduced from them directly, or by any legitimate and immediate implication, under the wholly subordinate relation they hold. These storms therefore cannot, it is believed, be taken in any case as a whole in the sense of a physical mass, and cannot be considered as masses or bodies revolving horizontally or spirally, and much less in a vertical or concentric manner. The phenomena which affect us, and those of winds particularly, are *incidents*, whose real position is more or less remote from the actual or original disturbance, and they are modified by many other agencies than that original cause. Not only in regard to these winds, but to nearly all other incidents or appearances, it is believed that an analysis and classification wholly independent of every hypothesis implying an identity of form, to which dynamic laws of any sort can be applied, can alone show what the order of phenomena is.

There are some general distinctions which it is necessary to make at the outset of the examination of storms in the temperate latitudes. The hurricanes, typhoons, and tornadoes, each of which more generally belongs to the tropics, frequently enter these latitudes in their original forms, and subsequently become blended with the forms which originate here, either by encountering one of these, or by putting on such forms by a gradual process of change. The West India hurricanes impress their character on a series of successive or continuous storms along the Gulf stream in nearly every case of their approach to temperate latitudes, and the tracks of these in the western Atlantic and along the coast, present the most frequent instances of the mingling of storms which were originally wholly different, with the widely extended rains above the 35th parallel. These widely extended rains begin at the season of hurricanes, August to October; and along a wide belt of the Atlantic to which the Gulf stream is central, as well as on the entire coast of the United States, the difference between the distances originating in the tropics as hurricanes, and the general rains originating inland, is merely one of degree. More or less of violence is exhibited in all the attending phenomena, and particularly in the winds.

Tornadoes have less connection with general storms, though they often exist as the nucleus of a general rain inland, and though belonging to the summer mainly, they are sometimes found in storms of mid-

winter. The term *tornado* is one properly limited to local storms of excessive violence, affecting but a thread of surface a few miles in length, and usually while no storm of consequence exists anywhere in the vicinity, but sometimes as the nucleus of an extended rain. The leading characteristic is intense electrical action, and several lines or threads of tornado force are sometimes developed in a wide stratum of air of high temperature with clouds and rain, particularly if in a cool month, or when the general storm is of much more than the usual excess of temperature. These may be exhausted after traversing a short path, and may again reappear, as well as when they occur in summer with an atmosphere generally calm; and this does occur without disturbing the general condition and without producing any conformity to their peculiar violence in the whole area covered by the rain, as the hurricanes of the Atlantic do. These last evidently control the movements of any storm or condition with which they come in contact, superadding to it the characteristics of hurricane violence until this violence becomes exhausted by distance, while tornadoes have no general influence whatever.

These two classes are radically different and distinct from the general rains which are usually designated storms in the temperate latitudes, and they will be left to a later place in the consideration. The more important practical and philosophical point is the law of these general rains or storms, and it is, in fact, *the simple law of the precipitation of atmospheric moisture in rain for these latitudes.* It belongs, also, almost entirely to the area of equally distributed rains, or of constant precipitation, and it is an incident of a process which is constantly going on, though with such irregularities and accumulations as to appear suspended at some times, and at others greatly intensified.

In the tropical tornadoes there can be no doubt that the general conditions are similar, and the violence is greater because the quantity of water thrown down is greater. Such as originate in the tropics and enter the temperate latitudes invariably return in their course to conform to the general atmospheric circulation, and they clearly do so because they attain the maximum of violence, and affect so large a volume of the air as to be controlled by the greater atmospheric movements where they occur. Rising through the lower mass, which is either calm or moves with the trade winds, they encounter the southwesterly current above and return with it, to be slowly exhausted in the wide spread rains of temperate latitudes. The question of greatest difficulty is to explain the fact that this occurs only at the eastern coast of the two continents; but there are several reasons why they should be so limited. There are no belts sufficiently heated

and saturated to originate then at the west of the continents near the tropics, and the necessary space fully to develop them is attained only at the western half of each ocean area. They attain their most perfect development naturally there, and the belt of warm water returning to temperate latitudes in the Gulf Stream, and in the Kuro-siwo, or Japan stream, is in each case itself a nucleus of disturbance, and it attracts the storms already forming. They sometimes skirt the south shores of the continent with great violence, but find no surface conditions permitting their progress inland. The fact that the surface atmosphere must constantly supply materials for reproduction and continuation is sufficient reason for the rarity of their extension inland, requiring the maximum of favorable conditions, as they do, to be perpetuated.

The primary statement in regard to the peculiar winter storms of the United States, as we designate them, though they are very little different from the general storms of the colder months in all temperate latitudes, is that they are large areas over which the excess of atmospheric moisture is falling in rain. From this simple view the exterior laws are easy of deduction, and other questions of origination, or those relating to the mode in which this excess came there, it is unnecessary to enter upon in defining the phenomena. It is evident that in the temperate latitudes a constant alternation of excess and deficiency in atmospheric moisture occurs,—using these terms in their relation to the average, of course, and not as positive conditions, since there is no standard in the case. The whole belt is one of *equally distributed rains*, in which every month and day is as likely as another to be one of rain and storm, and this general statement implies the constancy of the supply of moisture and of heat which make the temperate latitudes what they are. The precipitation of moisture is constant in a certain sense, but the elasticity and variable temperature permit absorption to go on at certain intervals farther than at others, and perpetuate alternations within the limits of the capacity of the air to sustain it. Otherwise the temperate latitudes would present perpetual clouds and mists sufficient to make up the rain fall for the year,—a condition impossible in an elastic fluid so mobile as the atmosphere, and operated upon by the forces generated when vapor is condensed.

The contrast between winter and summer precipitation, and the consequent storms of each season,—the showers in summer and the widely spread rains of the colder months,—is exhibited in the forms derived from the temperature apparently. In a heated atmosphere electrical agency, or some other necessary attendant of high temperature, limits the cloud formation to the cumulous form mainly, and therefore the precipitation is in showers in one case, and in slow and

steady rains in the other. The oscillation of conditions is greater in the cool months also, and the quantity of water falling is greater in proportion to the amount sustained in the atmosphere, inducing as much agitation and as violent winds as at any other time.

In noticing the winds it has been assumed that there is a belt of westerly winds in the middle temperate latitudes, which is constant at the height of cloud formation, and which appears as a resultant by reduction of the irregular winds at the surface. It is evident to any observer of the movements of the clouds, that a stratum above the scud and running clouds which attend most general storms, moves steadily from the west; and this is true of all the temperate latitudes here north of the 35th parallel in summer, and for the whole Gulf coast in winter; except, perhaps, the peninsula of Florida. The consequence of this general movement would be that areas of rain, or other results of changes, would themselves move forward in the same direction,—all the phenomena presented moving with the mass of air in which they occur. This panoramic feature is one of the most important to bear in mind, and it hardly seems necessary to fortify it by other citations than have been made in noticing the winds.

We have, then, an atmosphere moving steadily eastward as a whole, and changes of temperature and of the hygrometric condition of this mass constantly going on through a great range—heat and moisture are constantly supplied, and constantly dissipated and precipitated as a necessary consequence of exterior laws. The rivers are the constant measure of the water supplied, and the alternations of the seasons, with radiation in space, measure the heat. The alternations of heat and the precipitation of moisture naturally affect symmetrical areas and belts, and we so find both the conditions or extremes of the oscillation; and also, as the fall of rain is the most important material mark of these great disturbances of the surface equilibrium, they occur when this rainfall is profuse and general, and we have a general storm. In all this there is nothing but the most natural and inevitable consequence of the conditions stated, and all the variations are but those of a degree.

Whatever may be supposed necessary to account for tropical hurricanes and typhoons, and on this question it is not proposed to enter, no exterior agency is requisite to the production of all the phenomena of winter storms in the United States. It is not unreasonable that surface winds should be severe and even violent, and it is not unreasonable that they should blow from various points toward the disturbed district, as currents of water would rush towards an area of less density or a body being lifted. Nor is it inexplicable that in so moving, in or towards an area of change, a partially rotary movement should

be induced. This rotation is seen in any fluid volume subjected to disturbances of equilibrium, and in a fluid of great elasticity it is apparently cumulative to a certain extent, while the cause continues. All these incidents may be, and are, indefinitely varied as circumstances affect the case from without. The high temperature and great saturation are not always symmetrical, and over such areas may blend in part with another, presenting conditions which prevent all symmetry of the movements which are incidental, and which are consequences of more general movements.

The effort to deduce the law of these storms from surface movements has so much misled our habit of thought that some effort is necessary to attain accurate views of the order of the facts presented in these cases. Franklin and others long since determined that northeast winds do not come from remote points in that quarter, and that they recede with the general atmospheric movement and occur much later at Boston than at Pittsburg, when prevailing at those places during a storm.* And this is but an instance of the entire class, more readily observed because it is a more noticeable feature of storms, and more nearly reverses the general path they follow than others. Southeast and south winds are equally limited to the disturbance, being induced by it in the same manner, and not being themselves the cause.

The irregular presence of favorable conditions, and the intervention of new agencies of disturbance at the Atlantic coast, often prevent the regular march of storms, and they are sometimes reproduced or suddenly developed in such a manner as to put calculation at fault in regard to the most limited time of prediction. From the nature of the case it must be so, and the inconstancy of non-periodic phenomena of the atmosphere is at present beyond our power of solution. It is *probable* that a certain order of events will succeed each other when a large area of the temperate latitudes is precipitating a large portion of its suspended moisture in rain, but it is by no means certain that a definite order will be observed, and the succession may be very much broken up from causes exterior to the whole phenomenon, and wholly impossible of detection at the time.

In the colder months the change of condition, both as regards tem-

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* In a work of T. Pownall, M. P., entitled a "Topographical Description of the British Colonies in North America," printed at London in 1776, reference is made to a statement of this rule, by *Lewis Evans*, which I have not been able to find in the original, and therefore quote in Pownall's words ;

"I cannot close these observations (on climate) without transcribing from Lewis Evans' Map of Pennsylvania, New Jersey, and New York, printed at Philadelphia in 1749, the following curious, at that time novel and very curious philosophic propositions." "All our storms, says he, begin to leeward ; thus, a Northeast storm will be a day sooner in Virginia than in Boston."

perature and the quantity of aqueous vapor suspended, affects the whole mass in greater degree than when the rain is deposited in showers. For this reason the range of the barometer is greater, and this range is a very direct measure of the relative condition, so that the readings may be taken as simple representatives of the quantity of heat and moisture present compared with the average. If a deep and general atmospheric stratum is expanded by heat and saturated with vapor, its first expression at the surface may be the fall of the barometer, while the surface stratum may not participate in the change. It is well known that the stratum at the average height of the clouds often differs widely from that below in this respect, and when a considerable change occurs above, the depth of the stratum affected, and its volume relative to the whole mass, decide what the change of weight of the whole mass is, and how much the barometer falls. And this is also the measure of the agitation which will follow the removal of the excess of heat and moisture, or of the violence of the storm.

From this view the following order of phenomena is seen to be natural, if not inevitable;—first, the changes of condition giving an excess of heat and moisture; the attendant fall of barometer due to the displacement of denser volumes by these rarefied masses; the formation of clouds as the condensation commences; the institution of surface winds from nearly all directions toward the rarefied and condensing area; the fall of rain; the reduction of temperature; and the movement of all the phenomena forward in accordance with the general movement of the atmosphere in the latitude. If it is borne in mind that the resultant of the surface winds must be nearly equivalent here to the movement of the cloud-bearing stratum which we constantly see moving from the west, it is easy to understand why the west and northwest winds which form the last decisive movement of these storms are more violent than the others and of longer duration. The winds are the most obvious and tangible part of the process, and they are proportioned to the extent of the area affected and to the degree of the disturbance. Those from opposite points, or that cross the line at an angle, are most difficult to explain in the degree of strength and the duration we find them to have, but when the extent of the district over which condensation is proceeding in many of these cases is considered,—often of five to eight hundred miles in diameter, and nearly symmetrical in a round or oval form—it is clear that one, two, or three days, may be required for the passage of the body, from the time its influence is first apparent to the time its central line or axis is passed. In many cases this reverse movement of winds continues till all the rains and clouds are gone, and fair weather has succeeded, yet the west winds of increased strength are then certain to be felt,

though no clouds attend them. The detail is extremely variable, indeed, as must necessarily be the case under such a complication of forces in a mobile fluid open to so many causes of agitation as the air of temperate latitudes.

Most of the results in regard to our great storms have been obtained by simple induction from observations, and the easterly movement of the great mass of the atmosphere is so proved. The observation and examination of these general storms have been most laborious, since continued observations are necessary at many points to give all the facts required, but the great number of points at which they have been made during ten or fifteen years past has furnished enough of evidence for all general purposes of deduction. These results are stated in one form in the brief enumeration given in a former paragraph, which is as they appear if observed as distinct bodies. This is the general idea entertained of them, but one leading to erroneous conclusions in many respects. They may be stated more fully as follows.

1. The general winter storms of the United States often cover an area of from three to five hundred miles in diameter, which area is usually oblong or oval, with its greatest length from southwest to northeast.

2. They all move eastward with the westerly winds of the belt where they are formed, *and in a line with the isothermals of the month in which they occur*—coming from a point north of west at the Mississippi river, and leaving the Atlantic coast in a direction north of east. This course conforms in both cases to the course of the isothermals; or, in other words, they do not leave the measure of heat where they originate to go into colder or warmer climates.

3. Their movement is generally at the rate of movement of the air of these latitudes, or nearly twenty miles per hour; but it may be much greater, or very little.

4. They may be initiated at all points of this belt, and at any meridian, and they have, equally, no point at which they are more likely to become exhausted and to disappear than any other.

5. They are more violent at the Atlantic coast and at the Gulf Stream than elsewhere, because the contrast of land and sea air is there very great in the colder seasons, and because the direct line of their progress carries them into a belt of high temperature. When the contrast is not great, as in the warmer months, there is no decided increase of severity there.

6. They are more generally attended by northeast winds than any others during the first half, or the rarefied area almost always induces a draft from that quarter first, and it continues over most of the district in which a draft contrary to the general movement is created.

7. None of the winds from other than westerly points are winds of propulsion, or propagated from their apparent point of origin—they are all, including a portion from the west, winds of aspiration, induced by the agitation, or by the disturbance of equilibrium itself.

8. All the movements and processes are usually carried past the mean by the forces set in motion in these storms; the minimum of heat moisture, clouds and winds, following the removal of the excess of the first two; and this minimum, though a calm and quiescent state, is itself an extreme, and not an average condition in these latitudes.

These are substantially in accordance with the generalizations of others, and Espy gives something similar as the result of a very extensive examination and charting of storms of this class continued for many years. He gives their average movement at thirty-six miles per hour, and represents them as of greater length north and south than they are east and west. The rise of barometer which usually attends the serene interval he considers part of the storm, but it is such only in the sense that the other conditions of the oscillation are, the change in one direction necessarily creating its compensating change. The rise of barometer which sometimes succeeds an interval of generally high readings, does, however, appear to have some direct relation to the depression that is to follow, and it may in many cases be due to the cause assigned by Mr. Espy, which is, that the rarefaction proceeding at the point where the storm is about to begin heaps up the non-rarefied air in advance of it to some extent.*

* The writer also charted all the greater storms of 1850, 1851, and 1852, in a series of charts of four to twelve for each storm, with the same general result. The charts were drawn from all the observations at any certain hour for the whole United States; showing, for instance, the exact condition at 9 o'clock of the morning of a day preceding the commencement of any general storm, and at one or two hours of every day of its continuance at any point. On these charts the phenomena were seen to be initiated, to increase to their maximum degree, to move across the country, and to disappear both by exhaustion and by passing into the Atlantic beyond the reach of observation, precisely as the shadows of clouds forming and disappearing are carried across a plain. The attendant winds are not seen until the temperature and humidity rise and show an excess, and the barometer falls; then these strike up, more generally from the northeast than elsewhere, though very often from east and southeast, and they move across the continent with the shadow representing the area over which rain is falling, like the local currents created in a mass of water by moving a solid body in it. With the quantity of water precipitated, the violence of winds and the range of barometer are directly associated, and whatever may be true of abstract capacity of a mass of air to contain aqueous vapor without expansion of its volume, it is certain that the degree of heat attending its absorption, and the cooling attending or succeeding its precipitation, produce a direct effect first to increase, and next to contract the atmospheric volume. The result is a general contraction of volume directly proportioned to the rapidity of condensation, and all the winds and movements in-

There are many evidences strongly opposed to any dynamic theory of storms in these latitudes, except at sea, and they only need be referred to very briefly. The ordinary limit of cloud formation does not exceed six or seven thousand feet for the stratum of heavy cloud from which rain falls in these cases. With a surface area often over five hundred miles in diameter we have a proportion of five hundred to one for the vertical to the horizontal mass. A circular or oval mass of wood of these proportions may be imagined, substituting one foot for one mile, and by experiment with it the impossibility of applying to such an aerial mass any law of vertical or horizontal rotation becomes at once apparent.* Friction at the lower surface would alone defeat any propulsive force as a primary law, and friction at the exterior borders would also be sufficient to annul any horizontal rotary force. Vertical rotation, which would suppose the exchange of volumes from all points of the outside toward the centre below, and returning to the outer edge above, is still more obviously impossible; and the last hypothesis is, as a mere result of forces, wholly out of the question. To associate either the horizontal or vertical rotation with the progressive movement the whole phenomenon is known to have, introduces complications of the utmost confusion; and, in short, every distinct dynamic theory concerning these storms

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duced are of course so proportioned. This exterior generalization is so obvious that no analysis is necessary to sustain it; we see the partial vacuum created, and we see it supplied by violent movements of dense, cold, non-saturated air. The presence of the heat and moisture creates the partial vacuum in most cases before any rain appears, and it is evidently impossible that the barometric fall occurring over an area five hundred miles in diameter, central at Cincinnati, for instance, and having its greatest measure there, and all occurring with scarcely a perceptible wind at any point, should be a dynamic result, or should be caused by any simple movement whatever. In the typhoons and hurricanes the diminished pressure of the centre may be in part a dynamic result, as the forces are so violent that they may reasonably be supposed to accumulate such a consequence, whether it originates with forces simply or not. But in the interior of the United States nothing is more common than to find this diminished pressure commencing and increasing over a large area before any other evidences of approaching general condensation in rain appear.

* Dr. Hare has examined the two leading dynamic theories in regard to storms;—the rotary and centripetal hypotheses—in several able papers and by the aid of illustrative diagrams carefully contrived to show what the necessary movement must be if such are the true laws. In a criticism on Dove's paper—in which paper a general concurrence of that distinguished author with Mr. Redfield's views was expressed—Dr. Hare showed the supposition of a rotating disc to be an impossibility, particularly under the lateral and vertical changes of position which these storms were known to exhibit. Concurring in the facts of a partial spiral movement exhibited by these storms, and in the practical value of a knowledge of these facts, Dr. Hare concludes with the remark: "He (Dove) has, I think, committed a great oversight in neglecting to take into consideration the agency of electricity in the generation of storms." (American Journal of Science, vol. 44, 1843.)

as a whole utterly fails. Of course there are forces and mechanical movements to be considered, and particularly the general atmospheric movement so often referred to, but beyond this the law of storms is mainly the law of supply and exhaustion of heat and moisture under the oscillations which belong to every feature of climate in temperate latitudes. We find these changes to belong to considerable belts or areas, and to periods of time of from two to five days. They constantly succeed each other in temperate latitudes, and the panorama is perfected by the steady movement which carries the air forward along the thermal lines. About these areas and belts the sensible changes of clouds, falling rain, winds, heat, cold, and barometric variation, take place from the natural relations of heat to the suspended moisture, of both to atmospheric weight, and of a partial vacuum to masses of dense air adjacent to it.

The phenomena in detail are of constant and inexhaustible interest, however, and several of these storms will be cited here with a condensed statement of these facts. They are ordinarily given much more diffusely than is necessary, and if regarded or cited from a point of view giving them the wrong order of precedence, they might be multiplied without limit and yet fail to reach a positive result. In illustration of the appearances and succession of phenomena presented at one point in the cooler parts of the United States the following citations are made from observations by the writer at a point near the 42d parallel, on the plateau of western New York, about 1300 feet above the sea. The succession of instances of storm in rain or snow in the colder months is constant at that latitude, and the differences in this succession are only those of degree. Some cover large areas, and others are limited; some exhibit only incipient precipitation, or cloud formation without rain or snow, and every degree of extent and duration, from these merely preparatory forms of condensation, to the storm lasting three or four days. The impossibility of applying dynamic theories is very strikingly shown in such cases, since every degree of force is found in direct proportion to the variable degree of condensation.

In December, 1850, a great depression of barometer and a severe storm occurred with the following succession of winds, &c., the barometric readings are given in hundredths of an inch above and below the average, according to the signs affixed.

		Bar.	Ther.	
Dec. 21.	9 p. m.	+.09	29°	Wind and clouds west, few and light.
" 22.	Sunrise.	—.04	26	High stratum of clouds from W. S. W. threatening snow; wind
" "	9 a. m.	—.05	28	light S. and calm.
" "	3 p. m.	—.28	31	Wind at S. E. with fine snow; clouds at W. S. W.; rain at 5 p. m.
" "	9 p. m.	—.72	32	freezing as it fell, with clouds on the wind (S. E.) at 6 p. m. wind changing to E. and N. E. in night.
" 23.	Sunrise.	—.92	18	Change of wind at 12 p. m. to N. with snow and gale till morn-
" "	9 a. m.	—.76	20	ing; snow continued; wind N. N. W. to N. W.; clouds seen on disc of sun from west above.
" "	3 p. m.	—.38	18	Snow continued; still two strata of clouds; wind strong N. W.;
" "	9 p. m.	—.02	11	upper cloud at W. Storm ceased at 7 p. m.
" 24.	Sunrise.	+.24	10	Calm, thin frost clouds from N. W.
" "	9 a. m.	+.35	14	Light N. W. wind rising.
" "	3 p. m.	+.40	21	A few clouds and light W. air.
" "	9 p. m.	+.41	13	Calm, clear, and intensely cold.

In this case the barometric range was one and thirty-three hundredths inches, and nearly equal to the average entire range for the year; the range of temperature was very little, and the amount of rain and snow falling very great. The wind was light

west at first; then at S. and calm; next light S. E., E., N. E., and N. with great strength, continuing at N. W. strong to the close of the storm. This storm was of the less numerous class at that latitude which change from south by east to north and west again, and in these cases the centre of the disturbed district is usually south of the place of observation.

In the same month a storm occurred in which the change was in a reverse order:

		Bar.	Ther.	Wind.	
Dec. 6.	Sunrise.	+.20	29°	N. E. 1.	Dull clouds, with a little motion from N. E.
" "	9 a. m.	+.20	29	N. E. 1.	
" "	3 p. m.	+.15	32	E. 1.	A cloud stratum above from W. S W.; lower clouds
" "	9 p. m.	+.10	30	E. 2.	N. E. and E. very slowly; wind light, snow at evening.
" 7.	Sunrise.	—.43	32	E. 1.	Sleet and snow in night; rain at 8 a. m.; profuse; ob-
" "	9 a. m.	—.45	32	S. E. 1.	viously two strata; wind light; lower clouds slowly from S. E.
" "	3 p. m.	—.61	32	S. W. 3.	Rain till 3 p. m.; wind and clouds, slowly changing
" "	9 p. m.	—.36	25.	W. 4.	to west and wind becoming violent with snow at 4½ to 6 p. m.
" 8.	Sunrise.	—.15	21	W. 3.	Snowing slowly with high wind and clouds W. N. W.
" "	9 a m.	—08	21	W. 5.	
" "	3 p. m.	—.04	18	W. 4.	Snow squalls.
" "	9 p. m.	+.02	14	W. S. W. 3.	Clear and cold.

Of this class perhaps ten or twelve occur in the average yearly at that latitude, with the barometric range less than an inch, yet as much as three-fourths of an inch, and with little change of temperature if in the winter. The winds of the first half are usually light, and more likely to be strong at southeast than at other easterly points.

At such interior points they are rarely violent unless the conditions of surface favor it, as at the inland lakes; and the contrast of positions at these lakes and at points distant from them, is striking proof of the absence of any general system of forces moving the storms. At Buffalo the northeast and the west winds are often very severe and destructive to shipping, when at this point, eighty miles distant, they are far from violent. Another point is noticeable in this connection, which is the greater severity of easterly winds at lower stations, and of westerly winds at higher positions. At elevated points over the whole United States violent easterly winds are rare or unknown, yet they are perhaps the most severe of all the gales of the Atlantic coast. The east winds are inward drafts beneath an upper stratum moving from the west, and they are therefore strongest when the depth and volume they influence is greatest; while the west winds ascend with the upper movement, and are equally violent above and below, or at high and low stations.

In the year 1850 there were, at the point of observation quoted, fourteen general storms similar to those cited, though but two others were equal to the greatest given here. There were none in June, August, and November; one each in March, May, July, Sept. and October; two in each, Jan., April, and Dec.; and three in February. Some of these were unknown at the Atlantic coast, and others, particularly that of July, were excessively severe at New York and Boston. Of the fourteen *nine* changed from east by south to west, and *five* from east by north to west; and in all cases the upper clouds were carefully observed, and were found invariably from some point between W. S. W. and W. N. W.

As this is in brief the record for each point of the country north of the 39th parallel, the citation is directly pertinent to the question in hand. During three years the writer kept the record with the utmost care and minuteness, particularly in regard to the observation of the upper strata, which are so frequently obscured by lower clouds forming on the wind beneath. In nearly every case they may be seen at some moment of the day on the disc of the sun or moon, or at intervals in the break of

the lower clouds and scud. The uniformity of this motion from the west above was most striking, and it was never reversed unless some great storm was prevailing at the Atlantic coast, or at the south. There were but three instances in the three years so observed, 1849 to 1851, in which the stratum ordinarily bearing the rain or moisture of the storm, or the cirrus stratum, moved from easterly points. In one case, Sept. 1st 1850, a severe storm was prevailing at the south, and a watery cirro-stratus moved from the south above the clouds, coming from the west. In another case a very violent storm on the Atlantic coast gave a thin cirrus moving from N. E. above all other clouds.

This mode of observation gave unusual opportunity to judge from what aerial stratum the chief volume of water was deposited, and in this respect the agency of the stratum having a regular movement from the west in controlling the climate was most fully illustrated. In more than four-fifths of the cases of considerable precipitation, whether the form of the storm was regular or not, the *cirrus* was seen to thicken and become a dense stratum, lower than its ordinary position, yet retaining its course, and from this thickened *storm-stratum*,—readily distinguishable at all times, and, when seen, at once recognized as the source of profuse rain in all cases,—the rain or snow mainly fell. When it broke up, the several strata below would cause no fall of rain of consequence, though often running for hours before themselves disappearing; and when present, with or without the strata and scuds below, a considerable quantity of rain almost invariably fell. The most frequent stratum next below, from which rain sometimes fell profusely, was one from south or southeast; one from northeast rarely gave any other than a light mist; and in several cases of the presence of scud from N. E. the horizon in that quarter was free from clouds, showing the local origin it has, and the incident character of the winds and scud clouds.*

In one instance, October 6th and 7th, 1849, a singular and violent rain with southeast wind began without preparatory evidences at 2 or 3 o'clock a. m., of the 6th, at Jamestown, and the same storm began at New York City at 6 p. m., of the same day, in an equally sudden and violent manner,—at Boston at the same hour, and at New Haven a little later, as it is noticed; and at all these last named points continuing as a violent northeast storm for two days. The distance of three hundred and fifty miles was thus made in fifteen hours, or nearly twenty-five miles per hour as the rate of progress. It is worthy of note that the northeast wind at the Atlantic coast belonged to the whole storm, while at Jamestown it was at southeast the first day, then calm: then strong from north, and only at northeast at the close; clearing with a brilliant aurora on the night of the 7th, or not very long after its commencement at Boston. Many buildings were blown down in New York City at 2 to 6 a. m. of the 7th. This instance is cited to show that the most violent of these storms at the Atlantic coast may be subject to the same laws of progression eastward, and may be

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* Mr. Redfield (in American Journal of Science for 1831) gives a striking illustration of this incident character of the winds attending storms in a description of a storm which traversed almost the whole Atlantic coast from the south, originating, as many storms of the Atlantic coast do, in a West India Hurricane. It was felt at New York on August 18th, 1830. "The storm appeared on this part of the coast simultaneously with the prevalence of a northwest wind, *which maintained itself at a few miles distance for some hours after the setting in of the northeast wind at New York, the latter gradually extending itself up the Hudson.* During the whole period of the gale the extreme margin of the stratum of clouds pertaining to the storm was visible from the city, and it was elevated not less than 10° or 15° in the northwest horizon. The sun set during the height of the gale, and by illumining the lower surface of the dense canopy of clouds gave a most striking degree of splendor to the scene, an effect which was much noticed at New Haven and other places."

identified at various points in this respect, attended, however, by the greatest contrasts of wind and local phenomena. It is clear that the surface winds have no influence on the general movement of a stratum depositing the water of these storms, and that all their more important laws must be deduced from exterior facts.

Following this local description one of the most extensive barometric movements known to the records we have may be taken, or the most remarkable, rather, from the fact of the disturbance reaching from the Pacific coast to the Mississippi valley, and in some measure over the whole Atlantic coast. Its asserted and apparent connection with hurricanes and typhoons in the Pacific and East Indies, and with storms of the Baltic Sea and in England, will give the notices an interest as illustrating the great exterior barometric movements, which, perhaps, are not identical with our general storms in their mode of origin or in their laws of internal movement and of progression. The notices of the movement and storms of Dec. 31st, 1854 to Jan'y 3d, 1855, are mainly from the meteorological registers kept at the Military Posts of the United States. On Dec. 31st a great storm visited California, Oregon, the Colorado country, Lower California and the Sandwich Islands, according to the accounts of it published in California, and on January 1st severe coincident storms occurred at London and in the East Indies, and in all parts of the interior of the country west of the Rocky Mountains. On the two or three days following similar changes were felt in the Mississippi valley, but they were exhausted before reaching the Atlantic coast.

December 31*st*, 1854.

Puget's Sound . . .	At average temp.	Showery, .60 in. rain.	Wind S.	Continued rain of rainy season for 10 days previous.
Fort Vancouver . . .	"	Cloudy, no rain.	?	Do.
Fort Dallas, Oregon .	"	Light rain.	Wind S. & S. W.	Do. for 6 days previous.
Fort Orford	"	Rain in morn'g, .55 in.	Wind N. W.	Do. for 10 days previous.
Fort Jones	"	Snow .65 in.	Wind N. W.	Do. for 4 days previous.
Fort Humboldt . . .	5° warmer.	Rain .45 in.	Calm.	23d and 24th Dec. rainy.
Fort Reading . . .	5° warmer.	Rain 1.40 in.	Light N. & N. W.	25th rainy.
Benicia	5° warmer.	Rain .38 in.	Fresh E.	No rain previously.
San Francisco . . .	7° warmer.	Rain .55 in.	High S. E.	No rain since 3d Dec.
Fort Miller	5° "	Rain .80 in.	Light S. & S. W.	No rain since 2d Dec.
San Diego	Temp. & barom. at average.	Clear.	Fresh N. E.	Do.
Fort Yuma	Temp. at average.	Clear.	Light N.	Do.
Fort Defiance . . .	5° colder.	Clear.	Calm.	No rain since 3d and 4th.
Great Salt Lake . .	Average.	Cloudy.	Light W.	No rain previously.
Fort Massachusetts .	Average.	Clear.	Light N. W.	Do.
Santa Fe and Ft. Union	5° warmer.	Clear.	W. & N. W.	No storms since 3d & 4th.

Weather similar to that at Santa Fe at all posts of the Rio Grande in New Mexico; and at Forts in Upper Texas. Nearly clear and calm over the plains; in lower Texas; in the South Atlantic States and in all parts of the eastern States. The barometer generally at the average, though nearly .20 inches above the average at New York.

January 1*st*, 1855.

Puget's Sound . .	Average temp.	Nearly clear, snow in night.	Wind variable.
Vancouver . . .	5° colder.	Do.	Calm.
Fort Orford . . .	5° colder.	Rain and snow.	Light N.
Humboldt . . .	Average.	Rain, hail and sleet.	N. W. and N.
Reading	5° warmer.	Rain 1.50 in.	Light S. W.
Benicia	10° warmer.	Rain .50 in.	Hurricane at 2 a. m. from S. W., then high west wind. Barom. .60 below mean.
San Francisco . .	7° warmer.	Rain .50 in.	Hurricane at S. E. at 1 a. m., then high at west. "Barom. at 29.15 in., lower than ever before."

Fort Miller . . .	18° warmer in morn.	Rain 0.11.	Light S. W.
San Diego . . .	5° warmer.	Rain 1.60 in.	Strong S. E.
Fort Yuma . . .	Average.	No rain.	Light and variable.
Fort Defiance, N. M.	5° warmer.	Clear.	Do.
Great Salt Lake .	5° warmer.	Sleet and snow, 2 inches.	Gale from S. during day, and from N. at night.
New Mexican Posts	5° to 10° warmer.	No rain or snow.	Wind variable, and fresh S., in lower part of Rio Grande valley.
Upper Texan Posts	10° warmer.	No storm.	Winds high S. and S. E. No change of barom. at Fort Brown.
Eastern Texan Posts	20° warmer.	Cloudy, but no storm.	Wind high and violent S.
Fort Gibson & St. Louis	25° warmer.	Cloudy.	Wind very high S. Barom. low.
Fort Laramie . .	15° "	½ cloudy.	Light W.
Fort Kearney . .	8° "	¼ cloudy.	Light N. Barom. at average.
Fort Leavenworth	25° "	Nearly clear.	High S. W. Barom. at average.
Fort Snelling . .	15° "	Cloudy.	Wind S. S. E.
Lake District . .	5° to 10° warmer.	Cloudy.	Variable.
Central & Eastern States	5° to 10° warmer.	Pleasant or cloudy.	Light and variable.

The barometer ranges high at New York and vicinity, nearly half an inch above the mean. In Florida it is showery, and at Norfolk and Charleston the barometer is one-fourth of an inch above the mean. At London a sudden fall of barometer occurred with "a heavy gale from southwest."

January 2d, 1855.

North Pacific Posts	Average to 5° colder.	Snow all day.	Wind high S. E. on the coast.
Fts. Orford & Humboldt	5° colder.	Rain, hail, and snow.	High S. E., with hurricane from S. E. at night.
Fort Reading . .	Average.	Morn. clear, then rain.	Hurricane from S. at night.
Benicia & San Francisco	Average.	Rain.	High S. & S. W. wind. Barom. high.
Fort Miller . . .	Average.	Cloudy.	Wind E.
San Diego . . .	"	"	Wind S. W.
Fort Defiance, N. Mex.	5° colder.	(Rain and snow in a. m.)	Wind violent N. and N. E.
Great Salt Lake .	Average.	Snow day and night, 16 in's.	Strong N. wind.
Upper New Mexico	5° warmer and growing cold.	Snow in p. m.	Violent S. wind, changing to N. and N. W.
Lower New Mexico	5° to 10° warmer.	Nearly clear, no storm.	Wind S. and variable.
Western Texas .	10° to 20° warmer.	Do.	Wind fresh S. and S. E. Bar. at average.
Eastern Texas . .	20° warmer.	Do.	High S. winds.
Fort Gibson & St. Louis	25° warmer.	Do.	High S. winds.
Fort Laramie . .	5° warmer.	Slight snow.	Strong W. wind.
Fort Kearny . . .	25° warmer.	No storm.	High S. W., S., & S. E. Barom. falling half an inch.
Fort Leavenworth	35° warmer.	Cloudy, rain at night.	Wind violent S. S. W. Barom. half an inch below mean.
Fort Snelling . .	33° warmer.	Cloudy, rain at night.	High S. & S. E. winds. Barom. falls half an inch.
Lake District . .	16° warmer.	Cloudy.	Winds E. and S. E.
Florida and the South .	5° to 10° warmer.	Showery and variable.	Winds light and variable.
Fts. Columbus & Hamilton, N. Y. . . .	Average.	Clouds, but no storm.	Winds light; barometer .55 in. above average.

At London the barometer was .148 in. above the average, light rain and moderate weather; on the 3d the barometer was at 30.219, with calm and warm weather; the period from 30th Dec. to 9th January being from 4° to 13° warmer than the average for each day. The barometer rose from 30. inches at January 1st to 30.525 at the 9th, and it was similarly high at New York for a longer period, commencing earlier and ending later.

January 3d, 1855.

Pacific Coast of Oregon .	5° colder.	Clouds and snow in interior.	Strong and variable wind.
Fort Jones	10° colder.	Snow, heavy, 1.39 in.	N. light.
Fort Orford . . .	8° colder.	Rain and snow.	Wind W. in a. m., S. E. to W. S. W. a gale in p. m.
Fort Humboldt . . .	Average.	Rain and sleet, 1.10 in.	Wind N. W. to S. W. a gale.
Fort Reading . . .	5° warmer.	Rain 1.70 in.	S. W. gale at night.
Benicia	5° warmer.	Rain 1.00 in.	Wind high S. W. & S. Barom. 29.60.
San Francisco . . .	Average.	Rain.	Wind high S. W. and S.
Fort Miller . . .	Average.	Rain 3d and 4th, 1.37 in.	Wind N. E. and S. E.
San Diego	5° warmer.	Clear.	
Fort Defiance & Salt Lake .	5° to 10° colder.	Cloudy.	Moderate winds.
Northern New Mexico .	8° to 10° colder.	Clear.	Moderate winds or calm.
Western Texas . . .	5° to 10° colder.	Cloudy, slight rains.	Strong winds S.W. to N. & N.W.
Eastern Texas . . .	Average temp.	Clouds and moderate rain.	Winds S. to N. W. or N.
Fort Gibson . . .	Average.	Clouds and mod. rain.	Wind N. Barom. high.
St. Louis	15° warmer.	Moderate rain.	Winds S. W. and W.
Fort Laramie . . .	17° colder.	Clear.	N. W. light.
Fort Kearny . . .	20° "	Nearly clear.	N. and N. W. strong.
Fort Leavenworth . .	13° colder.	Do.	Do. Barom. high.
Fort Snelling . . .	10° colder.	Snow.	Wind N. W. Barom. high.
Forts Brady and Mackinac	25° warmer.	Cloudy.	Wind high S. E.
Cincinnati	20° warmer.	Cloudy, rain at night.	Wind high S. E.
Pittsburg	15° warmer.	Cloudy variable.	Light variable.
New Orleans and vicinity	15° warmer.	Clouds.	Fresh S. E.
South Florida . . .	5° warmer.	Clouds, showers, variable.	Fresh E. winds, and variable.
South Atlantic posts . .	5° to 10° warmer.	Cloudy and variable.	Variable and light.
Forts Columbus & Hamilton, N. Y. . . .	5° warmer.	Cloudy.	Wind light E.; barom. 30.50.

An easterly and northeasterly storm occurred in the upper lake district and as far south as Pittsburg on the 4th, 5th, and 6th, but it did not reach the Atlantic coast. The weather along the whole Atlantic coast continued moderate for many days.

Imperfect as the observations are from which this sketch is derived it clearly illustrates the variable origin and movement of what we call the great winter storms. On the Pacific coast two or three sudden changes of pressure occur, with violent winds in the districts affected; that of the night of Dec. 31st and morning of January 1st is repeated in the following days, though it appears to be carried eastward also. In each case the temperature is high before the violent wind and the fall of rain or snow occurs, and an extreme of low temperature succeeds the precipitation. With a uniform supply of moisture to the air we might anticipate this as the natural and almost inevitable succession, since the capacity to sustain moisture increases with the measure of heat, and when this has attained its highest point the reaction must necessarily throw down more or less of the suspended vapor.

East of the Rocky mountains the high temperature first, the fall of barometer next, and the attendant violent winds with a succeding rain, show clearly the natural order of these phenomena. The whole change was begun and ended also without reaching New York, and it would appear to have been restricted to the Mississippi valley because it had been fully instituted at the Pacific coast, and had nearly exhausted the excess of humidity before going east of the Rocky mountains. The "Storm" was primarily one of excess of heat and its dissipation, rather than an excess of both heat and moisture. No forces were developed, therefore, whose action would be propagated forward and sustained to the Atlantic coast and beyond it, where storms of this class attain their extreme severity.

It would mislead inquiry to cite any of these inland storms as a perfect representation of the class, since in some cases they go in directions and develop internal movements quite extreme and contradictory. In some cases the lower wind is continued during the passage of the whole stratum depositing rain; it may be at south-

east or northeast, and east of the Alleghanies this last point is much more prevalent than it is in the Mississippi plains. An extended storm occurred in 1852 in which the wind was at northeast during the whole period, and over all the area, which extended from southern Illinois to the Atlantic Ocean. On the 19th of February, 1847, a violent northeast storm began at Milwaukie at 10 a. m. snowing twenty-four hours; the same storm began at New York at 11 p. m. of the same day and continued to the night of the 20th. In this case the movement was unusually rapid, being over 50 miles per hour;* though such should not be taken as the measure of absolute movement, and it is without doubt in great part the extension of the area where the storm is forming.

In the extensive list of general storms charted by Prof. Espy a good opportunity is offered to observe the prominent features of movement they exhibit, though the distinction in regard to precedence of phenomena must never be lost, and the subordination of the winds as incidents, and not controlling agents, must be borne in mind. In the Third Report on Meteorology Mr. Espy gives a series of charts, one for each day, for eleven days, April 21st to May 1st 1843; on each of which some decided general precipitation or general storm occurred in the area between the 95th meridian and the Atlantic coast. It forms an extraordinary succession of phenomena which may be briefly sketched as illustrative of the subject in hand. Each chart is drawn for the hour of 3 p. m., from simultaneous observations at a great number of points.

On April 21st there is a moderate general rain in the west and southwest, mostly beyond the Mississippi. The winds are at N. E. at the lake district, and from Norfolk southward on the Atlantic; at other points at the south and west they are at S. and S. E. In the New England States they are from N. W.

On the 22d the rain and S. E. winds have moved eastward as far as New York, in most of the central states they are at S.; west of the Mississippi at S. W., and at some points about the lakes and in New England N. E. A line of low barometer extends from New Orleans to Lake Superior, and the maximum pressure occurs in Maine.

On April 23d the whole phenomenon has moved eastward so much that the line of low barometer connects Norfolk and Lake Ontario; the rain is heavy here and in New England; there is none from Cincinnati westward, and the winds are from the W. or various in the Mississippi valley, blowing toward the area of least pressure where the storm exists.

On the 24th the low barometer is at Boston and the rain is continued there, but N. W. winds prevail generally when the storm was the day before. West of Cincinnati the winds are again at S. and S. E.

On April 25th another area of low barometer appears at Fort Snelling, with abundant rains near St. Louis, reaching Cincinnati at night. In northern Maine the storm of the previous day remains yet. In the districts where rain falls the winds are mainly from S. and E., and S. W. west of St. Louis.

On the 26th the area of low barometer is in the longitude of Detroit, and east of this point there is a good deal of rain with light winds.

On the 27th the low pressure extends along the Atlantic coast from Charleston to Maine, but the rain is all south of Philadelphia. The winds are moderate, and blow towards the rain and area of low barometer.

On the 28th the winds are N. W. where the rain of the previous day fell, and rains again commence at the southwest.

On the 29th there is heavy rain central at St. Louis, though the line of lowest barometer lies westward, at Fort Gibson. The winds irregular, but generally toward the rain.

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* Prof. Dewey in Report of Regents of N. Y. University, 1847.

April 30th shows heavy rains central at Pittsburg, and covering a large area—touching Savannah, Boston, Montreal, Lake Superior, and Cincinnati. The winds are strong S. E. east of Pittsburg and south to Norfolk ; at Savannah and Charleston S. ; in the meridian of Cincinnati W. ; and at St. Louis N. W.

On May 1st the minimum pressure is at Boston ; east of Buffalo and north of New York rain is falling ; and the winds blow toward the storm generally.

It is remarkable that so many successive days exhibited this regular order of changes resulting in what we call a general storm, or in a widely spread fall of rain, with all the incidents attending it naturally. With an unusual saturation prevailing for this period all the oscillations of temperature induced general precipitation, and the obvious consequences were remarkably frequent.

Of the very large list charted by Prof. Espy this exhibits the usual result, though in many cases little forward movement was observed. The winds generally blew toward the area of low pressure from all quarters, though southeast and northeast winds were the most common on the east of this line, and northwest winds on the west of it. The extent of the area affected was, on the average, one-third of the area of the United States east of the 95th meridian ; sometimes the whole of this district was embraced, and frequently half of it. At several instances two areas of rain or diminished pressure were present at once, occupying the extreme points of this space, and it almost always embraced the extremes of barometer belonging to one agitation.

It will be borne in mind that these are the instances of most extensive rain fall in all cases, of which there is an average of perhaps three, monthly, for the coldest four months, with two each for the remaining months of spring and autumn, and one for each of summer. Below this grade the rains are of every degree of extent and frequency, and however local in appearance, as in the occurrence of two or three showers, or in the local, misty, continued rains of elevated points, in the northern States, the phenomenon is a degree of the same which produces the general winter storms ;—that is, a stratum or area more or less extended is saturated, and rarified by heat or otherwise so as to disturb its equilibrium and cause the deposition of moisture in rain. If local and limited in a thin stratum, no winds may be called in play, as is the case in light misty rains when it is generally cloudy ; and if local in the form of thunder showers, where a volume of great comparative depth is affected, though little in horizontal area, violent local winds will be developed which are also confined to a small horizontal area, though they have considerable depth.

It seems only to require the simplest statement of these apparent laws to suggest the amplest evidence of their general truth, and this evidence is constantly presented in daily experience. From the nature of the case uniformity in the surface movements and phenomena is impossible, and a dynamic law is out of the question. We can apply no rules of motion simply, and no law of simple forces as solutions of the phenomena, though simple material and simple chemical forces and laws enter as elements of the whole problem. If a planet were to undergo changes of density and volume in an absolutely irregular and non-periodic manner it would be impossible to compute its orbit and position at any moment, and the ceaseless oscillations in the measure of heat and of aqueous vapor in the air of temperate latitudes from exterior causes, must equally render the computation of the elements of a perturbation so induced, or so occurring from any cause, utterly beyond calculation ; since the primary and indispensable elements of the change are beyond the possibility of being known. If the exterior accession of heat and moisture could be accurately known, we might readily estimate the perturbations that would ensue in restoring the equilibrium they disturb, but these come, without doubt, mainly in a superior atmospheric circulation which is wholly inaccessible to us, whatever its character.

The conclusion in regard to this class of storms must be that they originate in changes of the measures of heat and moisture introduced from exterior sources, and

that these changes are absolutely non-periodic and cannot be foretold. And when present they are liable to an endless diversity of influences, dynamic, and of internal origin, the effect of each of which cannot be known because of associated influences acting on it alone. Thus with a given measure of primary disturbance we would suppose a wind from a certain quarter sure to follow, but the atmosphere in that quarter may be acted upon by disturbing influences in another direction which neutralize the first.

Generally the presence of a rarefied and humid mass, from which rain will fall profusely by the natural loss of temperature which must ensue after a brief presence in the temperate latitudes, will induce condensation first, winds from adjacent areas next—of which the principal at the east of the central line will be northeast and southeast, and those west of the centre northwest and southwest—closing at every point with a great reduction of temperature and high winds from west and northwest in the line of the general atmospheric movement. The whole will move eastward along the thermal lines, or from a point north of west from the Mississippi to the Atlantic coast, and from southwest across the Atlantic. The average rate of progress is that of the westerly wind of the latitudes, or not far from twenty-five miles per hour; they often move much faster, and still more often appear so to move when it is merely *formation in advance*, and they may also appear to move very slow when formation westward, or when exhaustion is in progress.

South of this belt severe general storms occur which have not such movement, and which are intermediate between those last described and the tropical storms. In Texas they are called "*Northers*" and they occur along the whole coast of the Gulf with great severity. They move eastward in winter, but not at other seasons, and they undoubtedly originate in the same conditions as the first, or those of excess of heat and moisture. And this excess is palpable at the surface, affecting the whole volume, and making the storm more violent accordingly at the surface. They are tropical storms, having a partial identity with the forms of temperate latitudes, and sometimes being transferred there. This condition of sensible heat and excessive humidity is always conspicuous and peculiar on the Gulf coast, showing that the lower atmosphere shares the changes.

When the conditions occur near the comparatively cold land surface of dry districts bordering the Gulf, as in Texas, the most violent wind induced is one from these cool land areas, a *norther* there, which is in remarkable contrast with the area of the storm in regard to temperature and humidity. As the contrast of conditions is then extreme, the winds are among the most violent belonging to any class of storms.

In September 1854 two marked storms occurred on the Gulf, one in Texas and one at the Florida peninsula, the last of which passed off along the Gulf Stream in one of the violent storms peculiar to the Gulf Stream. The last began Sept. 6th near Cape Florida and Key West, and continued until Sept. 14th, when it had reached the meridian of 35° W. and lat. 54°; the first named began later, and continued two days in lower Texas, and two days still later near New Orleans, though not severe here, and not known in Florida or at Charleston. The extreme southwest of Texas had little of it, as the following notices will show.

September 17th to 19th, 1854.

Forts McIntosh, Inge, Duncan, and Clarke, Rio Grande valley; winds S. W. and N. E. light; no rain.
Ringgold Barracks, Lower Rio Grande; slight rain 17th Sept.; winds N. fresh.
Matamoras (Fort Brown) Lower Rio Grande; rain on 17th wind N. E.; barometer falling .25 in. on 18th, with no rain.
Corpus Christi and vicinity; winds E. and N. E.; no rain.
Forts Chadbourne and Belknap, Upper Texas; winds E. and S. E. clear.
Fort Arbuckle, Northern Texas; winds E. and S. clear.

Brazoria, mouth of Brazos river, 17th violent N. wind at evening; 18th still more violent through entire day with heavy rain, and changing to northeast; 19th violent wind and rain from S. E. and S.

Columbus, Colorado river, Texas; 17th violent rain with east wind at evening; 18th continued and increasing: 19th gale from E. in morning; then calm; then south a gale, "then west; and finally to the N. from whence it blew as severely as it had in the morning from the east."

Galveston and vicinity; most violent from N. E. and S. E. blowing down a very large number of buildings in all the small towns; Houston, San Jacinto, Velasco, &c.

Fort Washita, N. Texas; slight fall of barometer on 17th; wind E. light, no rain.

Fort Smith, Arkansas; "during 16th and 17th two strata of clouds, one very low and moving mostly from the E. and the higher one occasionally visible in small openings and at a great elevation moving from S. to N.;" no rain; wind E. and N. E.

Fort Gibson, Arkansas river; slight fall of barometer 17th, wind S. light, a little rain.

Baton Rouge, La.; heavy rain 17th to 21st (5.55 inches) wind east but not violent; five days of storm.

Mobile; wind E. and N. E. cloudy 17th and 18th; 19th .66 in. rain; 20th 3.02 in. rain.

Pensacola; wind N. E. 17th to 20th light; 19th .60 in. rain; 20th 1.25 in. rain.

Key West; slight showers; no fall of barometer; no storm.

Fort Myers, lower Fla.; violent showers 19th and 20th.

Fort Brooke, Tampa Bay; nearly clear.

Charleston; no fall of barometer; light showers; wind E. and S.

In this case the storm was one of unusual violence, and though no barometer was observed at any part of the area where it was severe, there is no doubt of the great measure of the depression. The winds were extremely variable about its central district, which was a little west of Galveston, and they blew toward that point generally. Eastward the rains were continued for a day or two as far as Pensacola, though they were not violent; and at the Atlantic coast no traces of it appeared. At New York the barometer was half an inch above the mean for the 17th and 18th, falling to one-fourth of an inch below on the 19th, and immediately rising again. In short the whole storm was confined to the coast of the Gulf, and moved very little if any eastward. At the posts of upper Texas, Forts Chadbourne, Belknap, and Arbuckle, the S. and S. E. winds prevailed uninterruptedly while the violent N. and N. E. gales blew in the vicinity of Galveston.

The other instance enumerated in this connection belongs to a different class of storms; those which originate in the tropics and take the course of the Gulf Stream from the capes of Florida, following it substantially until they are lost in the Atlantic. The following notices of it illustrate the class. It was observed very carefully at Jacksonville, Fla., by Dr. Baldwin, whose notes will best show the succession of events at one point:

	Barom.	Temp. °	Winds.	Clouds.	
Jacksonville, Fla., Sept. 6th, 1854.	29.985	84.7	N. E. moderate; clouds briskly N. E.		
" 7th,	29.773	81.2	N. E. fresh to strong; clouds do. 5-10 in. rain.		
" 8th, 7 a. m.	" .432	81.	N. W. 6.	N. W. 6.	Rain.
" " 9 a. m.	" .399	81.	N. by W. 6.	"	"
" " 12 m.	" .395	75.5	W. 5.	W. N. W. 5.	"
" " 1¼ p. m.	" .415	75.	W. S. W. 6.	W. S. E. 6.	"
" " 3 p. m.	" .434	76.	S. W. 6.	S. W. 6.	"
" " 6 p. m	" .490	76.	S. S. W. 6.	S. W. 6.	"
" " 9 p. m.	" .630	78.	S. W. 4.	S. W. 4.	"(2 8-10 in.)
" 9th, 4 a. m.	" .714	80.	S. 4.	W. S. W. 4.	No rain.
" " 7 a. m.	" .784	82.	S. S. W. 5.	S. W. 4.	"
" " 2 p. m.	" .820	87.	S. S. W. 4.	S. W. 4.	"
" " 9 p. m.	" .895	84.	S. W. 3.	S. W. 3.	Nearly cloar.

On September 7th a gale prevailed at S. S. E. off Cape Florida which inoreased to a destructive hurricane on the 8th. At Charleston and Savannah it was more destructive in regard to inundations than any storm for many years, and the force of the gale was from northeast, east, and southeast; blowing fully on the shore, and inundating all the low lands. The wind was strong and constant from N. E. through the 6th, 7th, and morning of the 8th; when it changed to S. E. with equal severity. The

waters subsided on the 8th and 9th with strong S. W. winds. It was a hurricane at N. E. through the whole of the 8th at Savannah.

At Norfolk a violent N. E. storm commenced on the afternoon of the 9th, and continued over two days. The entire area of the Gulf Stream was at this time occupied by violent gales, mainly from N. E. At Washington a very profuse rain fell through the night of the 9th, and half the day following, with moderate wind and nearly calm. At Baltimore the same weather prevailed. At Philadelphia it began four hours later, and was accompanied with very high N. E. wind, prostrating buildings in some cases.

At New York the rain began at 9 p. m. of the 9th, and continued with heavy N. E. wind during part of the next day. At Boston it began at the same time and was violent at N. E. for thirty-six hours; two and a half inches of rain falling.

At sea this series of gales was continued to lat. 54°, and long. 35° west, at least; strewing the surface with wrecks in great numbers. In most cases the severe gales were N. E., though some of destructive severity were at N. W. on the western border of the line of storms.

Few barometers were observed in the line of the severe storms; at Washington the depression was slight, and at Albany a fall of near two-tenths of an inch occurred on the 9th. At sea the range was doubtless very great, though no positive measure is at hand. At Jacksonville, Florida, it exceeded six-tenths of an inch; at Savannah it reached one inch. (Dr. Posey.)

It is remarkable that so large a proportion of the area and time of this series of storms should have given violent N. E. winds, and that the whole western border was characterized by these as far as the storm was felt. In this respect it differs from the general form of this class, which usually have a large proportion of westerly winds at the border at least, and at sea as the storm recedes. From Boston to Norfolk the N. E. gale continued to the end, and at points farther south it was succeeded by S. E. and S. W. winds only. In other respects it is evidently similar to the class Mr. Redfield has so thoroughly examined and so well defined in many publications during the last fifteen years. The progress of these along the coast, their partial extension inland, and their apparent blending or identity with the general storms of the temperate latitudes here, are points very well shown in this case.

Mr. Redfield has treated these so ably that any particular examination of the general facts is unnecessary now; it is clear that the great storms of the Atlantic coast which are most destructive to shipping come up from the south along the line of the Gulf Stream, and usually from the tropics, where their progress or course is from E. S. E., recurving first at the peninsula of Florida, and again leaving the coast to cross the Atlantic nearly on the line of the isothermals for the season in which they occur. There is an axis of greatly diminished pressure, often so much as one inch below the mean, and a general rotation of the attendant winds from left to right, or at N. E. on the left and S. W. on the right of the phenomenon, looking in the direction of its movement. The rate of movement is set down by Mr. Redfield at less than 25 miles per hour at the south and until they reach the temperate latitudes, from which time they are rapidly accelerated, and attain fifty miles per hour in the higher latitudes.

Forcible as the evidences of dynamic agency appear in this class of storms it is believed that they are not subject to such laws, and that they exhibit violence proportioned only to the contrasts of temperature, and to the rapidity of condensation. The apparent rotation is, in part, the incident of their progress forward as a whole, and as we have seen in the case of the storm of Sept. 1854, it is far from uniformly true that any completeness of the rotary movement exists, and often the case that winds from but a single quarter are felt at the same moment over nearly all the area embraced. Regarding all these winds as incidents of the great contrasts of density and the rapid condensation of a moving mass of air the want of uniformity is easily

solved, but under a dynamic theory, involving rotation as an agency, these uniform movements become indispensable. Practically, the knowledge of this probable rotation is of great consequence and value, whether this theory of causation is applicable to the case or not.

This class of general storms of the tropical region is so important that it would be of the greatest service to all the shipping and agricultural interests of the south Atlantic States to obtain some knowledge of their general movement. They are not winter storms strictly, but hurricanes, and belonging to a "hurricane season" almost exclusively, which covers only the months of August, September, and October. Late in August and early in September they are most frequent, and they move along a line so much extended, and spread so largely in their progress northward that a rate of progress might be calculated, and their presence at the most southern point telegraphed.

As this chapter is in preparation a succession of extended and severe storms has occurred which very well illustrates the classes of violent and destructive character in the United States, though they are not exclusively winter storms. They are earlier and better defined than usual in each case, however, particularly that in the Gulf near New Orleans.

The first was on August 10th and 11th, 1856, and it may have come up from the southern portion of the Gulf, though it was apparently central at the coast of Louisiana nearly south of New Orleans. At Isle Derniere, or Last Island, it began with a high N. E. wind on Saturday, Aug. 9th, with a surf rolling with rapidly increasing violence from S. E. which indicated a gale in the distance in that quarter. This increased through the morning of Sunday, 10th, when the gale had changed to S. E. and was at its height, flooding the island and destroying everything on it. It was the extreme point of land S. S. W. of New Orleans, and occupied as a pleasure resort for the hot months. At Baton Rouge and New Orleans the wind was N. and N. E. at this time with torrents of rain; at Galveston S. E. a gale, but without rain. The whole storm had but a slight movement eastward, if any, and it appears to have exhausted itself on the lowlands of the coast in Louisiana and Mississippi.

The next was one originating in the Middle States, and occurring nearly at the same time on a line from Washington to Albany. In central New York, west of Albany, excessive floods of rain fell, but it does not appear at any point west of Rochester. At Washington it began early on Tuesday, Aug. 19th, with E. and S. E. wind and rain all that day; on the next day cold and strong west winds prevailed. At New York it began on Monday, 18th, continuing through Tuesday, 3.32 inches rain falling. At Albany it began early on Tuesday, continuing through Wednesday; at Boston on Tuesday night, lasting 36 hours. Along the New England coast and at Boston the winds were at N. E.; at New York and southward more nearly E. and S. E. In New York and the country eastward the rains were heaviest, causing great floods on the rivers. The wind was not violent at any point on the land, and too light to be assigned any agency whatever in the general movement or causation. It was followed by a week or more of very cold weather over all the country where it prevailed.

Another of unusual violence and extent began as a Cuban Hurricane at or beyond Sagua la Grande, on the north shore of Cuba, on August 27th; on the 28th it was central at Havana, causing great destruction to the shipping in the vicinity, and injuring crops extensively. From this point it moved toward New Orleans, being encountered by the ship *Daniel Webster* at lat. 26° 30′ long. 87° as a terrific hurricane of over two days' duration. The barometer of this ship was at 28.6 inches at this point. It recurved eastward before reaching the meridian of New Orleans, and struck most violently at Mobile on Aug. 30th, ranging over the whole coast eastward to Appalachicola. At the outer islands of Mobile harbor the surf was terrific from southeast, and at sea between this point and Havana the first half of the storm was from N. E. and the last and most severe from S. E.

At Montgomery and Eufala, Alabama, and at Columbus, Ga., it began at noon on Saturday, Aug. 30th, continuing twenty four hours ; "strewing the towns with prostrate trees and fences, and blowing down many buildings." The wind was here from N. and N. E. At Milledgville and Augusta, Ga., and at Edgefield, S. C., the same severity of winds existed, with excessive floods of rain. At Savannah violent southeast winds occurred with but little rain, and at Charleston it was the same, showing that the central line of the storm was inland, and not, as usual in these cases, along the coast or out at sea. At Charleston the gale was on Aug. 31st.

In the interior of the Carolinas the storm was very violent, with northeast winds and floods of rain; at Goldsborough, below Raleigh, *snow fell for an hour or more* on the evening of Sunday, Aug. 31st. At Wilmington the gale was violent on Sunday night with floods of rain. Great damage was done by floods on all the interior rivers of the Carolinas.

At Norfolk a violent northeast gale blew on Sept. 1st, injuring shiphouses at Portsmouth, and doing injury at sea off Norfolk, though less here than in the Gulf. At Washington the wind was at east and northeast with threatening clouds on Sept. 1st, but no gale ensued and no rain fell. The same appearances were observed at Baltimore and Philadelphia, which last point was the extreme limit of observed disturbance.

From the first observed point in Cuba the whole storm traversed ten degrees of latitude and thirteen of longitude to reach its return point near Mobile, and its northeastern course crossed eight degrees of latitude and at least thirteen of longitude to arrive at its central point off the lower part of Chesapeake Bay; it probably extended much farther along the Gulf stream in the Atlantic. Along this track of sixteen to eighteen hundred miles in length its progress averaged nearly fifteen miles per hour, and the distance from Sagua la Grande to Norfolk was traversed in about five days.

In all these cases the more violent winds were northeast in the temperate latitudes north of the 30th parallel, and south of that they were tropical hurricanes.

This last hurricane strikingly conforms to the curves drawn by Mr. Redfield of a considerable number of similar storms, and its track was nearly identical with one of August, 1851 ; going a little farther west than that, however.

In Georgia there is a recognized hurricane district which is identical with that permitting the growth of tropical fruits, and embraces the counties along the Atlantic with those of the southern border of the State. The hurricanes of tropical origin constantly recurve along this coast, and approaching from the south or southeast return northeastward nearly in a line with the Gulf Stream to the high temperate latitudes when they retain their force sufficiently to carry them so far. Many of these are out at sea so far as to be felt but moderately on the coast, and some not at all, but the more commom track is very near the actual coast line for the centre of the storm, or its track of greatest violence.

In the following list some effort has been made to collect those known to our history, as a basis of induction in regard to their frequency, severity, and course of movement. Previous to 1800 the notices are of little value beyond mere citation, but for the period of Mr. Redfield's attention to them a very complete knowledge of all important facts has been attained. Those accredited to Mr. Redfield are from his charts and papers in the American Journal of Science for 1832, 1846, 1854, and several other years ; a list of the earliest is from Ramsay's History of South Carolina, and other historical sources.

List of Hurricanes on the Coast of the South Atlantic States, and on the North Coast of the Gulf of Mexico.

1700,* Sept. 16th. (*Ramsay.*) "Sea rushed in upon Charleston with amazing impetuosity."—Many lives lost.

1713, Sept. 16th–17th. (*Ramsay, Lamboll.*) "The great hurricane, attended with an immense inundation from the sea." All the vessels at Charleston except one driven ashore.

1723, —— (*Barton.*) "A remarkable hurricane visited New Orleans this year, and nearly destroyed all the buildings."

1728, Sept. 14th. (*Hewat, Ramsay.*) Town and lowlands of Charleston inundated; twenty-three ships driven on shore and mostly destroyed, &c. Weather very hot preceding it.

1752, Sept. —— (*Chalmers.*) "The two hurricanes which happened in Sept. 1752 were scarcely perceived 100 miles back in the country, though the first raged for ten hours," &c. (Weath. & Dis. of S. C.)

1752, Sept. 15th. (*Prioleau, Chalmers, Ramsay.*) The whole summer very warm at Charleston; all the vessels in the harbor driven ashore and some of them six miles inland over the marshes and small streams; the inhabitants taking refuge in the upper parts of their houses as in each previous case. "The hurricane of 1752 very far exceeded, both in violence and devastation, that of 1804." (Dr. Prioleau, from Dr. John Moultrie.) "All wooden houses above one story in height were either beat down or shattered; many gable ends of houses were blown out." Trees which were stripped of their leaves again blossomed and bore fruit in the late autumn which followed. (Ramsay.)

1756, —— (*Lyell.*) An instance of the flooding of St. Simons Island, coast of Georgia, referred to by Lyell. (*Second Visit to U. S.*)

1772, 31st August to Sept. 3d. (*Gayarre.*) A destructive hurricane in southern Louisiana though not so great at the city of New Orleans. The sea was driven over the islands along the coast of the Gulf. East of Lake Borgne the wind was from the sea (E. S. E.), but farther west it blew with the greatest violence from N. N. E. and E. Towards Mobile it destroyed the woodlands for thirty miles inland—spray was driven four or five miles inland in heavy masses and showers. Mulberry trees subsequently blossomed and bore the second crop of fruit.

1778, Oct. 7th to 10th. (*Galvez, Gayarre.*) Cited by Gayarre as very destructive to coast establishments near New Orleans.

1779, Aug. 18th. (*Gayarre.*) Cited by this author as of less severity than others.

1779, Oct. 7th to 10th. (*Galvez, Gayarre.*) "It raged with such violence (in lower Louisiana) that the sea was higher than ever before, entirely destroying all the establishments at the Belize, Bayou St. John, and Tigouyou."

1780, Aug. 24th. (*Gayarre.*) This swept over the province of Louisiana, destroying all crops, tearing down buildings, and sinking every vessel or boat which was afloat on the Mississippi river. The Intendant, Navarro, issued a consolatory circular to the inhabitants.

1780, Oct. 3d to 5th. (*Redfield.*) October 3d, at the western part of Jamaica; 4th at Cuba; 5th in the Gulf of Florida. (*Am. Jour. Sci.*, 1837.)

1780, Oct. 10th to 18th. (*Redfield.*) Oct. 10th at Barbadoes; 12th north of Jamaica; 16th off Havana; 18th near Bermuda. Both these storms of 1780 are no doubt imperfectly traced, and it is probable that they are like others.

1797, Sept. —— (*Drayton.*) "The tide rose some feet, and overflowed the wharves at Charleston; vessels were damaged and driven from their moorings."

1804, Sept. 3d to 9th. (*Ramsay, Drayton. Redfield, Lyell.*) Sep. 3d at Antigua; 6th at Nassau, New Providence; 7th at Charleston; 8th at Norfolk; 9th at Boston, &c. This kept near the coast and was very severe; "at 10 P. M. of 7th the gale began at northeast, at 7 a. m. of 8th it was at east with redoubled force; in the afternoon of the 8th it was at southeast and did not decline in violence till 10 p. m." Houses were blown down, wharves destroyed, &c, at Charleston; immense damage was done on the coast of South Carolina and Georgia, but it did not extend beyond Wilmington, N. C. (Ramsay.) After this gale fruit trees flowered and bore fruit a second time. (Ibid.)

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* Drayton (View of South Carolina, 1802) mentions a severe hurricane in 1699, but it is likely from the description that that and the one cited by Ramsay in 1700 are the same.

"In the 138 years since the settlement of Charleston, several minor storms have passed over without exciting any permanent public attention, but four have done extensive mischief and are particularly remembered. The first was in 1700, the second in 1728, the third in 1752, and the fourth in 1804."—Ramsay Hist. S. C. 1809, vol. II. p. 314, &c.

1811, ——— (*Dr. Barton.*) Hurricane cited in Dr. Barton's report, at New Orleans.

1811, Sept. 10th. (*Niles' Reg.*) At Charleston. A continued gale with heavy rain from northeast through Monday, Sep 9th, and to 10 a. m. of Tuesday, 10th, when it suddenly changed to southeast. At 12½ p. m , a violent tornado struck the city, passing from southeast to northwest in a line 100 yards wide, destroying many lives and an immense amount of property. In violence it was next to the Natchez Tornado, and it was apparently an incident of the great storm of West India origin then prevailing.

1812, August — (*Drake.*) At the mouth of the Mississippi; the Balize inundated, buildings washed away, &c.

1813, Aug. 27th. (*Niles' Reg.*) At Charleston ; many persons drowned and vessels lost—the coast inundated, &c.

1814, July 1st. (*Niles' Reg.*) A violent tornado at Charleston, apparently central to a general hurricane as in the case of Sept. 1811.

1815, Sept. 18th to 24th. (*Redfield.*) At St. Bartholomew's, Sept. 18; New York 22d; coast of Rhode Island on morning of 23d, "awfully destructive from southeast," &c.

1821, ——— (*Dr. Barton.*) Cited as one of the hurricanes experienced at New Orleans.

1821, Sept. 1st to 4th. (*Redfield.*) Sept. 1st north of Porto Rico; 2d off St. Augustine; 3d at Norfolk; 4th at Portland, Maine, &c. This is distant from the coast at Charleston, and the track is drawn in a line too nearly directly northward to be conformable to others.

1822, Aug. —— (*Papers.*) Severe on the coast of the Carolinas.

1824, —— (*Lyell.*) A hurricane flooding St. Simon's Island. Ga , in this year, is mentioned in Lyell's *Second Visit to U. S.*

1827, Aug. 17th to 27th. (*Redfield.*) Aug. 17th at Barbadoes; 19th near Hayti; 24th east of Charleston; 25th off Cape Hatteras; 27th east of New York; 28th east of Halifax. This was central to the Gulf Stream through its whole track, and nearly midway between Bermuda and Charleston. Mr. Redfield gives 11 nautical miles per hour as the ratio of movement of this storm.

1829, ——— (*Bonsignes, Lt. Webster.*) The date of this is not given more nearly, it was an inundation of the coast at the Rio Grande.

1830, Aug. 10th to 19th. (*Redfield.*) Aug. 10th at Barbadoes; 12th at Antigua; 15th at St. Augustine; 16th between Charleston and Norfolk; 18th off Boston; 19th at Newfoundland. This followed the coast from the south of Florida to Norfolk, and then passed off on a line more easterly than usual. Progress 17 geographical miles per hour; width of whole storm 5 to 600 miles; of hurricane 150 to 250 miles.

1830, Aug. 22d to 27th. (*Redfield.**) This storm has a similar general track, but lies farther east than the last. Its path divides the distance between the West India Islands and Bermuda on the south, and between the Atlantic coast and Bermuda through the entire curve of its course. Off Cape Hatteras its duration was 42 hours.

1830, Sept. 29th, 2d Oct. West India Isds. to Grand Banks of Newfoundland, at the east of the usual track.

1831, Aug. 10th to 18th. (*Redfield,* 1832; *Berlandier.*) At Barbadoes Aug. 10th; 13th East of Cuba; 14th at west end of Cuba and Havana; 16th near the north shores of the Gulf south of New Orleans; 17th and 18th continuing on the coasts of the Gulf, inundating the Balize and sweeping away houses, and wasting in heavy rains inland. This did not reach the Atlantic coast, though in all respects like those that do so by the longer route west of Florida, and the crossing of the lowlands of the north of Florida. The rate of movement was 13½ nautical miles per hour by Mr. Redfield's calculation. It was very destructive at the Rio Grande in lower Texas.

1831, ——— (*Barton.*) Cited by this author as one of the storms inundating New Orleans.

1834, Sept. (?) (*Lopez, Bonsignes, Lt. Webster.*) A hurricane is enumerated for September of this year by these authorities in a list of those destructive on the coast of lower Texas since 1828. (Lt. Webster's survey of the coast at the mouth of the Rio Grande, 1848.)

1835, Aug. 12th—18th. (*Redfield, Berlandier.*) At Antigua, &c. on the 12th; 13th Porto Rico; 14th Hayti and Turk's Island; 15th Matanzas and Havana; 16th Tortugas and the central districts of the Gulf toward New Orleans; 18th at Matamoras, Mexico. "It went to Galveston, but was not felt at New Orleans." This is one of the hurricanes which are exhausted in the western areas of the Gulf and on the coast of Texas without returning eastward to the higher latitudes.

1837, Aug. 2d. (*Dove.*) At St. Thomas and Porto Rico Aug. 2d. At first a hurricane from N. W. 2 hours; then a dead calm 45 minutes, then hurricane S. E. 6½ hours.

1837, Sept. 27th to Oct. 10th. (*Berlandier, Lopez, Redfield.*) Sept. 27th south of Jamaica; Oct. 1st at Yucatan; 2d and 3d at Matamoras, destroying the town of Brazos Santiago, and inundating the coast for many miles inland (Berlandier); 5th at Galveston; 6th near New Orleans; 7th at Mobile; 8th near Charleston; 9th and 10th passing off E. N. E. from Charleston southward of the usual line.

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* Mr. Redfield gives in his first chart the track of another in 1830, which lay midway between the Florida coast and Bermuda, and which begun in the latitude of Florida on Sept. 29th, reaching Newfoundland Banks on the 2d of October. As it is omitted from his second chart, it may have been thought in doubt.

1837, Aug. 12th to Aug. 23d. (*Reid, Redfield.*) On Aug. 10th this began at 50° W. long. in the latitude of Antigua; it came near the coast at Savannah and Charleston, and returned to the same meridian at the 41st parallel on Aug. 23d. No other dates are given.

1838, —— (*Bonsignes, Lt. Webster.*) At Brazos Santiago. But one of the authorities cited by Lt. Webster mentions this as flooding the coasts at the lower Rio Grande.

1840, —— (*Bonsignes.*) This is mentioned in the list cited by Lt. Webster. It is not known whether this extended elsewhere, but the coast villages near the mouth of the Rio Grande were either greatly injured or destroyed.

1842, Aug. 30th to Sept. 9th. (*Redfield, Lopez.*) This pursued a nearly direct line westward from its point of origin in long. 63° W. to the coast of Mexico at Tampico; the track lying between the 21st and 30th parallels. First observed in lat. 25° 54′, long. 63° W. on Aug. 30th; Sept. 1st north of Turk's Island; Sept. 3d south of Nassau, N. P.; Sept. 4th between Key West and Havana; 5th S. W. of Tortugas; 6th south of New Orleans in lat. 25°; 7th S. E. of Matamoras; 8th between Matamoras and Tampico; 9th wasting at sixty miles inland from Tampico. This inundated the coast at the lower Rio Grande. The body of the hurricane passed over the south part of the peninsula of Florida on Sept. 4th. Its track was nearly due west at a mean rate of 10½ statute miles per hour. (Redfield.)

1842, Oct. 2d to 9th. (*Redfield.*) First observed October 2d at Tampico; Oct. 4th, 5th off Balize; Oct. 5th over a large part of the peninsula of Florida, central a little north of Tampa Bay; 6th at St. Augustine and Charleston; 9th north of Bermuda, and going more directly eastward than usual. Appalachicola and Charleston were on the northern border, and Bermuda on the southern. At New York the barometer was very high, 30.10 to 30.46 on 4th to 7th. This was a *norther* on the Mexican coast. Immense numbers of sea and land birds were killed and found floating at sea. Progress less than 10 miles per hour.

1844, Aug. 4th—6th. (*Berlandier, Lopez.*) "The most terrible and destructive of any, though very little rain fell (at the Rio Grande). Not a vestige of a single house remained at Brazos Santiago or at the mouth of the river. The waters of the sea were forced up three leagues from the beach." (Berlandier.)* About seventy lives were lost at this point. The Mexican custom houses and stores were withdrawn from their former positions after this storm, and the coast was abandoned as insecure.

1844, Sept. 14th. (*Hist. Ga.*, &c.) Severe at Charleston on this day, but not traced elsewhere.

1844, Oct. 4th to 7th. (*Redfield, Espy, Thrasher.*) On both coasts of the west end of Cuba Oct. 4th; Oct. 5th at Key West; 6th east of Charleston and central to the distance between Charleston and Bermuda; 7th off Halifax, &c. This was terrific on the south coast of Cuba, 158 vessels were wrecked, and 2546 houses destroyed. (Humboldt's Cuba, *Thrasher.*) Very destructive at Key West alone. This is thought by Mr. Redfield to have developed a second, which passed one to two days later along its track in the Atlantic.

1846, Sept. 11th to 21st. (*Redfield.*) At St. Vincent Sept. 11th; Porto Rico 12th; west of Bermuda 17th; east of Halifax 20th; and passing at the west and north of the British Islands as drawn by Mr. Redfield. This did not appear on the coast at Charleston.

1846, —— (*Barton.*) Cited by this author as inundating the coast near New Orleans.

1846, Oct. 6th to 14th. (*Redfield.*) Beginning at the south of Jamaica it is traced nearly northward by Havana, Cedar Keys, the interior of lower Georgia on the 12th; the interior at Washington on the 13th; and near Quebec on the 14th. This track must be regarded as very doubtful in the north. It was very severe at Havana and Key West. (Key West and Havana papers.)

1848, Aug. 22d to Sept. 3d. (*Redfield.*) Began near Antigua Aug. 22d, passed Turk's Island and Nassau, N. P.; returning eastward lower than usual, and reaching 45° north lat. and 35° W. long. on Sept. 3d.

1850, Aug. 23d —— (*Papers.*) Appalachicola and Marianne, Fla. (Not at Savannah.)

1851, Aug. 16th to 28th. (*Redfield, Allston.*) Aug. 16th at 50° W. long. east of Antigua; 18th Porto Rico; 20th Havana; 22d between Havana and New Orleans; 23d at Appalachicola; 24th in interior at Augusta, Ga.; 25th near Norfolk; 26th lat. of Philada.; 27th lat. of Halifax. This was farthest inland or westward of any storm charted by Redfield, and its track was very nearly like that of Aug. 27th to Sept. 1st, 1856.

* Berlandier says in a communication to Lt. Webster, "The epoch of the inundations caused by storms on the coast (of lower Texas, mouth of Rio Grande) is variable, but in general they happen every three or four years from the month of August to October. The inundations of the Rio Grande have very little to do with the damage done by the sea either at the Brazos Santiago or at the mouth of the river. Those of the coast are caused by storms which take place near the West Indies or in the Gulf, especially when the east wind has prevailed for a long time and with great force. One single storm has been, according to my observations, caused by the rarefaction of the atmosphere on the continent itself." As the result of this inquiry the coast was reported untenable for military or naval depots.

1853, Aug. 30th to Sept. 11th. (*Redfield.*) This was the most extensive on record. Mr. Redfield devotes much space to its investigation, and it appears to have begun on the coast of West Africa at 17° N. lat., passing slowly W. N. W. above or north of most of the West India Islands, going to 75° W. long. off Charleston, on the 6th and 7th, and then returning northeastward twice as rapidly, and passing on the line of the Gulf Stream toward Iceland. It was felt in various ways at all exposed points of the coast, and particularly at Cape Hatteras; Mr. Redfield designating it the *Cape Verde and Hatteras Hurricane.* (Am. Jour. of Science, 1854.) In the path of the storm the depression of barometer was *two inches* below the mean.

1854, Sept. 6th to 14th. (*Baldwin, Posey,* &c.) First noted off Cape Florida on the 6th; 8th at Jacksonville, Fla.; 9th at Charleston; 10th at Norfolk; 11th at Boston, &c. The whole area of the Gulf Stream was occupied with terrific storms and gales, and though great quantities of water fell inland the central line was doubtless some distance from the coast. At Savannah Dr. Posey's barometer fell to 29.04 or nearly an inch below the mean.

1856, Aug. 9th to 12th. (*Barton, New Orleans papers,* &c.) This hurricane produced a fatally destructive inundation of portions of the coast south of New Orleans, Last Island (Isle Derniere) particularly. (See previous description.) At New Orleans 13 inches of rain fell. (Barton.)

1856, Aug. 27th to Sept. 2d. This very recent hurricane, "the most disastrous since 1846," is thrown farther westward than any other from Cuba; the first notes we have of it are from the east of Cuba Aug 27th, where it was very destructive; it was central at Havana on the 28th; central midway from Havana to Mobile on the 29th, with the barometer (steamship D. Webster) at 28.6 inches; between Mobile and Appalachicola on the 30th; and Montgomery, Ala. and Milledgeville, Ga. on the 30th and 31st; at Edgefield, S. C. and Goldshorough, N. C. on the 31st; and at Norfolk Sept. 1st. It then passed eastward at a low angle, not reaching any northern city as a storm, though there were threatening appearances as far as New York.

Since the preparation of the list here given, the corrected edition of Johnston's Physical Atlas of 1856 has been received, which gives, in a similar arrangement, a list of 127 cyclones or hurricanes occurring in the West Indies in a period of 354 years, or from 1493 to 1847. Nearly all the references relate to phenomena in the West Indies, and to effects produced there, which is a field not embraced in the purpose of this work; and very few citations mention the United States at any point, when the storm doubtless extended to the coast somewhere. Some incidents are of sufficient interest in this connection to be transcribed.

The first hurricane on record was experienced by Columbus in 1493 (Feb. 12,) in the North Atlantic; and three others are described by him previous to 1502.

In September, 1759, the Tortugas were flooded by a hurricane from N. E.

In 1780, Oct. 10th and 12th, a terrific hurricane devastated Barbadoes, killing 4320 persons,—"a 12 pounder gun was moved 140 yards"—this reached Florida.

In 1806 four hurricanes succeeded each other; Aug. 30, Sept. 13, Sept. 27, and Oct. 5; each very destructive.

In 1831, Aug. 10, the whole of Barbadoes was laid waste; "2500 persons perished, and 5000 were wounded." "A piece of lead 4000 pounds in weight was lifted and carried 1800 feet." This came near the U. S. coast but did not quite reach it.

In 1842, July 12, "upwards of thirty vessels went ashore near Cape Hatteras," the storm passed over Washington and extended inland.

In 1844, Oct. 3, a furious Cuban hurricane of the 4th is supposed to have reached Canada on the 9th and 10th—destroying houses and vessels on the Lakes.

In 1846, Oct. 11, the lighthouses at Key West and Sand Key were swept away, and over twenty vessels were lost on the reef at those points.

— Other agencies than simply the force of wind must account for the extraordinary cases of lifting weights so frequently noticed in these hurricanes, and the convective electric discharge is an obvious and adequate solution of the facts.

This is far from forming a complete list of the hurricanes of these three months, August to October, which came northward along the Atlantic coast into temperate latitudes and became general storms. Though rarely going inland at all, and never as far as the Alleghanies, or in any part of the Mississippi valley, they affect the commerce and agriculture of the coast more than any others in consequence of their excessive violence. They are particularly severe on the rice plantations from their effect in flooding the fields, and scarcely a year passes without serious injury to some part

of these on the Atlantic coast. Sea Island cotton is often beaten and blown out in such storms, also, and the shipping of the crowded track to Havana and Key West suffers immense injury. All the severe storms of this coast and the Gulf of Mexico cause flooding tides in the shallow waters, sometimes thirty to forty fect above the mean; with a terrific surf, particularly when the wind is fair to bring the swell upon a beach, as it sometimes is for two or three days.

The vicinity of New Orleans is by no means exempt from these hurricanes, though they appear to be limited to the coast there usually, as has been remarked in regard to the Northers of Texas, instead of recurving along the Atlantic coast northward as most of those east of Mobile, and as all do east of the Florida peninsula. Some of these are mentioned in the early history of Louisiana as of great importance to the interests of the colony from their terrible severity. Gayarre mentions one on the 31st of August to 3d of September, 1772; which was very moderate at New Orleans, though very severe in the neighborhood. "The sea was driven over the islands," submerging the lands along the coast at the south and east of New Orleans; where the wind was at S. S. E., flooding the lakes and inlets with a great swell of waters. West of New Orleans the wind was from N. N. E. and E. with equal violence. On the coast toward Mobile, woodlands were prostrated for thirty miles from the sea in many places, and the spray fell in heavy showers four or five miles inland. (Hist. La. p. 74.)

Another in Oct. 7th to 10th, 1778, destroyed all the establishments at the Belize, Bayou St. John, and Tigouyou. (Galvez in *Ibid.*) Another on August 18th, 1779, occurred at the same locality; and one of still greater severity than any before noted, on Aug. 24th, 1780, "swept over the province, destroying crops, tearing down buildings, and sinking every vessel or boat which was afloat on the Mississippi or lakes." A circular was issued to the inhabitants by the Intendant Navarro, consoling with them on their losses. (Gayarre.) William Dunbar, a resident of the vicinity of Natchez, and a distinguished member of the American Philosophical Society, described those of 1779 and 1780 in a communication to that society (Trans. Amer. Phil. Soc. Vol. VI., old series) in which he assigns a terrible degree of severity to that of 1779, himself being at New Orleans at the time, and that point being the centre of its severity. It was at first terrific in fury from southeast, then a singular calm of a few minutes followed and a sudden bursting of the wind from the opposite quarter. Half New Orleans was unroofed, the vessels in the river sunk or driven on shore, the forests prostrated, and trees and shrubs stripped of their leaves for "ten or twelve miles both north and south," and many strong buildings blown to pieces.

The materials for a complete history of these storms unfortunately do not exist, and it can only be said that they are less frequent than those occurring farther eastward and in the Atlantic. Some of them undoubtedly connect eastward with the class before described, and some are brought up from Cuba and the interior of the Gulf without going farther than the coast here. The most severe of those that come up from the southeast are most likely to recurve on the extended path along the Atlantic coast to high latitudes.*

* *A Chronological Table of Cyclonic Hurricanes which have occurred in the West Indies and in the North Atlantic from* 1493 *to* 1855, is noticed as having been presented to the British Association at its last meeting by Andres Poey, Esq. of Havana. "It comprises a list of four hundred gales and hurricanes, with summary descriptions and references, and explanatory notes; also a bibliographical list of 450 authors, books, and periodicals where interesting accounts of hurricanes may be found. Of the number of hurricanes cited by Mr. Poey as having occurred in the West Indies and Atlantic Ocean the monthly distribution of 355 was as follows:

A supplementary notice of another class of storms coming naturally in connection with the hurricanes, though not directly related to the general winter storms, may be added here. They are the *tornadoes* of the summer, or of the warmer months, which in rare instances appear also in the cold months as the nucleus of a widely extended and violent general storm. Great attention has been given to the special phenomena of these tornadoes in the effort to determine their dynamic laws, and the tracks of several have been accurately and minutely surveyed, defining the position of prostrate trees and of all objects moved by the wind. A spiral involute movement along a line but a few rods in width has often been found to exert a tremendous force without the slightest exterior disturbance, and to exert it alike whether a severe storm prevailed generally, or whether the air in the immediate vicinity was perfectly quiescent. Little difference is presented between the reverse and the forward movement when the whole body moved at a rate of thirty miles an hour; nearly as great force being exhibited in one direction as another. On the whole there are inexplicable phenomena connected with these storms, and the terrific energy they exhibit can be explained only on the supposition that electrical and magnetic forces are added in their extreme intensity to the ordinary violence of air in violent motion.

It is not proposed here to discuss the dynamic theories of these tornadoes which have been urged. It is certain that their phenomena are very variable, and that no single rule of motion applies to all cases. They are generally involute spirals, revolving with the sun; but they are often evolute, throwing trees outwardly from the centre instead of inward, and they sometimes revolve in a reverse direction, or from left to right.* In many cases little evidence of revolutions exists at the surface, and the phenomenon has the appearance of a travelling vacuum, toward which everything is simply and directly drawn, and in these cases trees are thrown in a line with the general movement for most of the track, the sides presenting angular positions pointing more nearly at right angles to the general line as the distance from its centre increases. In all cases there is evidence of the most intense electrical energy, the whole mass glowing with it, and evidences of force being constantly present which could only be induced or exerted by electric discharges, though these discharges never occur in the form of lightning and thunder.

There are so many features of identity with the hurricanes in the atmospheric conditions which generate the land tornadoes that it must be conceded that they are different only in degree, or in dimensions. The same nerveless lassitude is felt, and want of elasticity in the air before they appear, which is but an expression of the peculiar electrical state which exists. The same excessive heat and excessive saturation exist in both cases, and this general condition doubtless originates the fearful displays of electric energy and atmospheric force which form hurricanes at sea and tornadoes of greater or less area on the land. The greatest difficulty exists in explaining the facts in regard to their narrow limits while the fullest measure of violence is retained, and this can only be done on the supposition that electric energy makes up a very large share of the force.

January	5	July	24
February	7	August	96
March	11	September	80
April	6	October	69
May	5	November	17
June	10	December	7

Of this list those reaching the coast of the United States would doubtless occur mainly in the three months, August to October, and certainly within the five, July to November. (American Journal of Science, Nov. 1856.)

* Col. Reid saw at Bermuda a water spout revolving in a reverse direction, and in the small dust whirlwinds this is frequently the case. (Am. Jour. Science, 1843.)

In those which show a great preponderance of electric energy the form of an inverted cone is most common, and the land storm and water spout do not materially differ. This cone may sweep the earth with a narrow point but a few yards wide, and it may be lifted from the surface altogether at intervals, coming down again as violently as before. Incomprehensible as the force exerted by a proboscis-like column of air projected from a broad inverted base in the clouds, and varying its position in height and otherwise, as a solid mass might be lifted and swung, there is no measure of force known to us which exceeds that of this column a few yards in diameter, traversing a body of air generally calm. The few which have occurred as the nucleus of a widely extended rain storm, have had no greater violence than those of the narrowest line in a still day of summer.

The frequency and distribution of these tornadoes is a subject of practical interest, as in the case of the hurricanes. They occur over every part of the United States where the rain fall is abundant, and at the seasons of its greatest abundance. There are none on the great plains so far as known, at a distance from the Mississippi sufficient to reach the dry regions; they are most numerous in the Mississippi valley, and from this eastward they are quite equally distributed from Canada to Georgia. In the old forests, particularly of New York and Pennsylvania, the tracks of those which prostrated the older growth a century since may still be traced by the belt of trees of uniform size and peculiar aspect which grew up subsequently. The earth hillocks are thickly crowded over the soil of these belts, on all tracks where the soil readily turns up with the roots of trees. From the clue to frequency which such tracks give, these storms must be placed at very remote intervals for any one locality —the permanence of such a forest trace could be relied upon for at least five hundred years, and they now exist in only a few conspicuous lines, averaging fifty miles distant perhaps, and lying in threads of thirty to two hundred rods in width, and ten to fifty miles in length. The tracks are so narrow that great frequency would be required to mark the entire surface, yet it must be concluded that they are not more frequent than the hurricanes, while the space they cover is the smallest thread in comparison to those gigantic displays of atmospheric disturbance.

A list of nearly forty described tornadoes in the United States had been prepared for this place, but space renders it impossible to give it in full. The following are types of the class.

Cincinnati, Ohio, May 28th, 1809. (*Drake.*) Three separate tornadoes at a few minutes' interval, near 2 p. m.; each very narrow, and within the area of the city. A general rain was falling, with violent cross currents among the clouds. Several tornadoes were formed about the same time in the western parts of Ohio, Kentucky, and Tennessee; a principal one "ascended the Alleghanies in the afternoon." A general condition favorable to the formation of "concentrated veins of this hurricane" existed over a large area at the time.

Charleston, Sept. 10th, 1811. (*Niles' Reg.*) Central to violent storm of West India origin; exhibiting the lurid appearance and funnel shape peculiar to these tornadoes, and shifting its position very much. It occurred at half-past 12 m., immediately after a calm interval in the southeast gale then prevailing. Many buildings were destroyed, and lives lost. It compares in violence with the Natchez tornado.

New Brunswick, N. J., June 19th, 1835, 5½ p. m. *Prof. L. C. Beck* describes this as at times a double cone, one base resting on the surface; it travelled E. N. E., through New Brunswick, Piscataway, and Perth Amboy, to the ocean. Its track exhibited variable phenomena of prostration of trees, &c. The most striking appearance was the cone or funnel, and its variable position as it moved forward. The waters of the Raritan river were wholly removed from its bed. The track was visited and surveyed by Profs. Bache and Espy.

Natchez, Miss., May 7th, 1840. (*Tooley.*) This is the most destructive yet observed in the United States. It was the nucleus of a somewhat general rain. "The day began warm and cloudy, wind S. 4, veering to E. 5; at 1 p. m. wind a gale N. E. and E.; at 1h. 45m. p. m. the sky became a lurid yellow, the storm striking the river 6 or 7 miles below the city, reaching it at 2 p. m. The rush did not last more than five minutes, and the destructive blast but a few seconds. The barometer fell to 29.37, the wind S. E., blowing inward toward the annulus. Houses

were burst outward, and the central point was a vacuum action. 317 persons were killed in the city and on the river. Sheet tin was carried 20 miles, and windows 30 miles. The direction of the track was from W. S. W. to N. E. and E. N. E. The effects of the storm upon the leaves and buds of plants was in a measure to sear them, abstracting so much of their vitality that such as did not die outright were crisped, and their growth so suspended that it was ten days or more before they resuscitated and began again to grow. Some very thriving grape vines were killed,—even the succulent morus multicaulis appeared as if an eastern sirocco had passed over it." (Tooley.)

Medford and Cambridge, Mass., Aug. 22d, 1851. (*Brooks, Eustis.*) A very distinct "form" was exhibited by the cloud in this case, usually that of an inverted cone, though often that of a double cone or hour-glass. Several "concur in saying that the conical point let down from the cloud moved about at short distances, now pushing down to the earth, and now rising from it. Its side motions were compared to those of an elephant's trunk. This action was like the descending tube in a nearly completed water spout at sea." Its width was from fifty to seventy rods; its course from W. S. W. to E. N. E., curving slightly; its rate of motion nearly "fifty miles per hour;" duration "five or six seconds." Its destructiveness was unusual in respect to the crushing of objects in its path, panes of glass were perforated and fused by electric discharges, and other evidences of intense electric action were exhibited. There was no whirl; trees were thrown inward and forward, most of the path presenting trees prostrated in a line with the general course of the storm; at the borders many lay at right angles to that line.

New Harmony, Ind., April 30th, 1852. (*Chappelsmith.*) This is traced from near Paducah, Kentucky, northeast to New Harmony, and from that point 200 miles nearly east to Georgetown, Kentucky, apparently following the general line of the Ohio river. The day was generally cloudy and threatening, with a low barometer,—the tornado occurred at 4½ p. m. At its point near New Harmony, the track of fallen trees was one-half a mile to a mile in breadth, and the rate of progress calculated at nearly 60 miles per hour. The destruction was the work of a moment, and intense electrical energy was apparent; an observer says: "the cloud appeared on fire at the bottom like a large pile of burning brush;" others describe it as a "cloud with green and red flame; others green and blue." Trees were prostrated outward as well as inward, but generally by an inward spiral. No wind or other agitation was experienced at four or five miles distance from the track.

Brandon, Ohio, Jan. 20th, 1854. (*Stoddard.*) This was the most violent of several partial tornadoes forming in a widely extended general storm in which the temperature was very high. At Mt. Vernon, Knox Co., it travelled ten miles East by N. E.,—its width nearly a quarter of a mile, and duration two to five minutes. Before it came up the air grew very warm, and the wind lulled. It appeared like "a column of vapor and smoke, whirling with indescribable confusion," exhibiting the most terrific electrical energy. Several partial paths, at distant intervals, were traced by one or several tornadoes,—one was in Washington County, Penna., and another in Arkansas. The barometer fell to 28.21 at Brandon; excessive saturation was exhibited, and "the walls of brick buildings were dripping with moisture." Prof. Stoddard gives the velocity of the tornado in Knox County at 45 miles per hour, and that of the general belt of low barometer at 29 miles. Direction N. E., and E. N. E.

XIII. CLIMATOLOGICAL RANGE OF NATIVE FORESTS AND VEGETATION.

BEFORE the occupation of the North American continent by civilized nations, its vegetation necessarily expressed some distinctions of climate and cultivable capacity which should be definitely understood, and which should be borne in mind under all circumstances of subsequent change. The extent of the common forests of deciduous trees; the portion occupied by forests of the resinous class, pines and cedars; the space covered by tropical evergreens; and the area destitute of forest growths,—each reflects some peculiarity of climate too important to be passed over. Changes subsequently occur in all civilized countries, and in some it is now disputed what the original condition was, and whether, consequently, permanent changes of climate have ensued. The removal of forests is designated by some as the cause of the present aridity and barrenness of portions of the shore of the Mediterranean through its whole extent, and of the diminished population of the historic nations of the east. The south of Europe has undoubtedly been denuded of a great amount of forest, and in that climate only—not in the north of Europe—is it possible that climatological changes have ensued. It is, also, still generally held that the removal of forests in the United States has modified the climate of the eastern States;—by some that the extremes of heat and cold are greater, and by others that they are less. It is particularly supposed that the quantity of rain has been diminished, and one well-defined fact exists, which is that the rivers of moderate size are much less in volume after the clearing of the country than before. The Genesee river in New York affords a marked example, being much smaller for the warmer months than it was twenty or twenty-five years since. Woodland rivulets which had considerable volume while the forest remained, disappear when it is cut away. Sudden rains, however, throw off greater floods on an open surface than in a forest, as is often seen on the prairies of the United States; and the whole change of conditions is limited to the surface, and is one merely dependant on the retention and slow evaporation in the forest, in contrast with the rapid drainage and prompt evaporation on the open surface.

Dove has cited several facts of the failure of springs and streams on the occupation of a country, with their renewal when abandoned to forests again;* and though he applies them to the proof that the quantity of rain changes, attributing its causation to the forests, he urges an inquiry on the extended districts of the United States on the point whether this removal of forests effects permanent changes of climate.

Nearly all the area first known to Europeans as the United States was covered with dense forests, mainly of deciduous trees, and stretching through all climates from sub-arctic to tropical. The New World was inseparably associated with the idea of these impenetrable woods, and it is not yet understood, as it should be, that for the whole temperate latitudes here the proportion of forest differs little from that of the eastern continent. From the west, or the Pacific side, the area of forest would only have been reached after passing over vast areas remarkably deficient in wood, and *plains* would have been taken as the distinguishing American forms. As in many other respects where discrepancy is supposed to exist, there is greater correspondence between the two continents in temperate latitudes than would be inferred from any received point of view.

There are three great divisions of American forests, apart from the immense area which has little wood on the best localities, and on vast tracts none. Each of the great divisions may have many subordinate ones, in part dependant on climate, but more on soil in most cases; but these minor distinctions are too numerous to trace in the present purpose. Peculiarities of soil also sometimes neutralize climatological distinctions, and confound species of plants so as to mask the local distinctions of climates.

Distinctions dependant on altitude are of little importance here in comparison with Europe, and only two or three points occur in the eastern United States where any positive limitations appear. These are at the White Mountains in New Hampshire, and at the still loftier Black Mountains of North Carolina; the first failing to produce trees at all above 5000 feet, and the second being crowned with a forest of balsam firs of small size, with a dense undergrowth of laurels and rhododendrons. For the rest the contrasts belonging to altitude are unimportant. The birch abounds in such forests as exist at the arctic circle, and for all the distance southward to the 41st parallel it is common in the woodlands, both of the general surface and of the highest mountains—in the last positions having the same aspect as in the subarctic forms.

* Essay on the Distribution of Rain in the Temperate Zone, Poggendorff's Annalen, No. 94, and Amer. Jour. Science, Dec. 1855 and Jan. 1856.

The principal deciduous trees of the northern forests are more decidedly limited, however, and they more distinctly mark the humid climates of moderate temperature and equally distributed rains. The beech, and maple; the ash, elm, linden or basswood, oaks, chestnut, cherry, poplars, hickory and walnut, magnolias, with many others, make up the remarkable mixed forest of the northern and central States—a forest which has no parallel for the diversity of species collected in a growth of trunks having nearly the same size, and thriving on the same soil and in the same climate.* It has been for centuries the distinguishing feature of the new world in every form of practical interest, and it has only very recently yielded to the tide of population so much as to be traversed and occupied through to the open plains. Now that this has been done the practical value of the heretofore formidable woodlands is seen with clearness, and some conception of the grandeur of this feature of the climate—as it is primarily climatological—is impressed on the occupants of the country.

Many of these forms are peculiar to America, and they would thrive neither in the British nor German woodlands. The heat and elasticity of the dry periods are evidently as essential as the abundance of rain in some form. Where these conditions exist, with no other interruption than change of temperature simply, such as occurs from the Gulf of Mexico to Canada, the mixed forest has the same permanence and with the same leading features. The intrusion of the prairies at the west is the only exception, and this is remarkable as proof of the existence of peculiar causes preventing the natural development. The more reasonable inference is that the presence of high plains at the west of the prairies, with a climate unfavorable to forests, has perpetuated obstacles to the first growth of wood on these prairies—periods of severe drought occurring annually, and fires sweeping over where the plain permitted. Very rich and diversified woodlands line the rivers and broken ground among the prairies proper, proving that neither soil nor climate limit their growth until the border of the dry plain or plateau is reached, nearly at the 98th meridian.

Next to the great mixed forest of leaf-shedding trees, which is so peculiarly American, are the forests of coniferæ, which are also remark-

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* Gray distinguishes this as "*The Middle and Northern Wooded District*, taking in the whole breadth of our territory along its northern boundary, but narrowing rapidly toward the south in a wedge-like shape. A line drawn from Fond du Lac to the western end of Lake Erie, and thence south to the Tennessee line, would serve tolerably well for its western boundary." (Amer. Jour. Sci., May, 1857.) Darby gave the dimensions of this "ocean of woods," or of compact forest mainly of deciduous trees, which so long gave the predominating character to the new world as seen from the old, as about 2000 miles long by 1000 miles wide—making 2,000,000 square miles—and bounded by the Atlantic, the Gulf of Mexico, and the naked interior plains.

able for ample growth. Some species of pine and cypress are limited by climate as the deciduous trees are, but generally the resinous woods are less distinctive of any such conditions. Even on the Pacific coast the quantity of rain makes no distinction, the finer varieties growing with nearly equal freedom on the western slopes of the Sierra Nevada at the south, where very little rain falls, and on the like exposures of the coast range at Puget's sound, where the rain fall is excessive. In the desert interior, however, where the summer heats are very high, the larger forms fail, and a variety of dwarfed growths appears.

In the eastern States the white pine at the north, and the yellow pine at the south, mingle equally with the variable constituents of the woodlands, though generally taking nearly exclusive possession of the localities of favorable soil—probably only because their compact growth crowds other forms out. In British America the belt of low evergreen forest has a wide extent about Hudson's Bay, and it is continued into the northern States above the 42d parallel. North of the great lakes spruces, larches, and low pines are the leading forms, but the white pine is the most abundant and important from Montreal to central Pennsylvania, to be followed at the south by an equally decided ascendancy of the yellow pines. With the yellow pine the cypress also comes in, with enough of distinctive climatological adaptation to mark a zone of its own. Less important forms intermingle variously with these, and it cannot be said that the climate of the eastern States especially favors or repels the coniferæ as a class. On the plains, and in the Pacific climates, however, the deciduous forests are decidedly repelled, and for the last districts the coniferæ are particularly favored, affording the finest evergreen forests known in the temperate latitudes. Even in the interior plateaus these forms are more varied than those of much of the transition belt in Asia and the north of Africa.

The detail of this forest distribution has unusual interest both in its specific climatological relations, and in all points of the practical physics of the country; but space compels the most limited citations in this connection. Almost all of the deciduous trees of the mixed eastern forests show some peculiarities of range and adaptation here which are founded on climate, in the widest sense of the word. The maple is rare in Europe as a large trunked forest-tree, while here several species have a large and uniform growth in the original forest. The sugar maple (*a. saccharinum*) appears to be nearly coincident at the north with the limit of Indian corn. It was found by Richardson near Lake Winnipeg, and Owen describes its abundance and usefulness on the river bottoms in the first belt of forest encountered from the west, lying along the highlands south of Lake Superior, and occupying localities in the upper parts of Minnesota, Wisconsin, and Michigan. Near Lake Superior on the north it reaches its climatological limit, disappearing from high and exposed localities; and it also fails on the highest ridges of the plateaus, and on the mountains of New York and New England at 2500 to 3000 feet above the sea. Though preferring the loamy non-calcareous soils of these states—to which the popular term "beech and maple lands" is

applied—the sugar maple goes almost to the Gulf of Mexico in the Mississippi valley in some localities. Though very rare east of the Alleghanies south of Philadelphia, it is quite abundant in Kentucky and Tennessee, on the Ozark hills in Missouri, and at some points in Arkansas. Darby found some trees of black sugar maple (*acer nigrum*) between the Sabine and Red Rivers of Louisiana at the 32d parallel. The primitive formations east of the Alleghanies repel it as much as the climate probably.

The beech shows a range quite similar, following the positions just indicated very closely, except in the especial preference of alluvial soils. There is a form of stiff clay of the tertiary and chalk formations which favors the beech to the exclusion of the maple—giving the fine beech forests of England, and of the western slope of the Alleghanies and Cumberland Mountains. The beech forests of Italy appear to be similar, and the three localities last cited show that great diversity of some of the climatological features at least, may permit a heavy growth of this tree.

Other species of maple than that named are almost universal in American climates, the soft-wooded species giving two or three fine tree forms in the north, with every degree of less solid growth, and with sub-aquatic varieties, which become most completely such at the Gulf coast and at the Pacific in Oregon. The soft-wooded maples are next to the poplar, also, in following river alluvions in the interior and Pacific districts generally.

The elm has two species of ample trunks in the north, and it pushes northwestward on the rivers somewhat farther than the sugar maple, though generally its limits and preference of soil are the same. The black cherry, tulip tree (*liriodendron*), and cucumber tree (*magnolia acuminata*) all furnish fine trunks and a liberal growth as elements of the diversified forest of the latitude of New York; with climatological limits like those before named. At the South the magnolias furnish a variety of remarkable forms, but the northern magnolia has its home in the heavy northern woodlands, though following the high forests of the Alleghanies some distance southward.

The ash has two species, of which one, the white ash, is remarkable for size and beauty as a northern forest tree, and another, the black ash, occupies cold and wet soils in a smaller form. The poplars and cotton-wood or "sycamore" (*platanus*) make up a large share of the free growths of the interior woodlands on alluvial or prairie soils. They prefer a warmer belt than most of those before named, and they follow over the whole prairie and mountain surface of the interior where water is found, almost without regard to other limitations.

The oaks and chestnut follow European rules, and rarely afford any distinctive illustration. The last has nearly the same preferences of soil and temperature, preferring hills and mountain sides, though sometimes coming nearly to sea level on favorite soils as far south as Maryland. Most of the species of the walnut and hickory are similar, though they go in warmer climates and farther south in the Mississippi valley, and also at the borders of the plains. Texas has a favorite climate for an associated species—the abundant Pecan nut.

The American linden, or bass-wood, is a characteristic of the great mixed forest of the northern States, going as far as the sugar maple northwestward. The European linden differs little from it.

The sub-tropical tree forms begin to be abundant in Ohio, and southward they increase in number rapidly until they become exclusively tropical in the oranges, palms, live oaks, and mangroves of the lower half of the Florida peninsula. The papaw, cypress and gum trees commence in the Ohio valley, while long-leafed pines, cypress, and live oak appear on the Atlantic coast at Norfolk; evergreen magnolias, palmettoes and the wild olive, follow before reaching Savannah, and the border of the Gulf affords many constant forms equally marked as tropical. The forest of the coast at Charleston is rich with tropical forms, red and white bays, giant laurels, cabbage-palms, live oaks, &c. At St. Augustine the wild orange is added, and in the southern

part of the peninsula satin-wood, mahogany, and mangroves; the mangrove becoming established in tropical abundance at Indian River, lat. 28° north. (Maj. Whiting, Am. Jour. Sci. 1839.)

Dr. Stinnecke, U. S. A., has recently referred to the original growth of live oak as yet remaining on the point of land occupied by Fort Monroe, and from this remarkable extension northward it increases slowly, lining the coast only, to New Orleans. Some of the points in Florida furnish a growth which has been made the care of the government to preserve, yet it never gets far from the coast, and it is quite interrupted near the Sabine River. West of this point it again becomes abundant, and in the southwest of Texas it goes over the highlands of the interior quite to the Pacific coast. It has been found in a somewhat dwarfish form at the more elevated points throughout nearly the whole line.*

The detailed distribution of the Pines and their congeners is worth following if the space permitted, though the point is more decidedly one of economical botany, perhaps, than of climatological distinction. A belt from the Mississippi eastward along the 45th parallel includes the best tracts of white pine, with a growth of unequalled value for economical purposes. The highlands of southern New York and northern Pennsylvania are a part of this district, but not much is found elsewhere, and it is doubtful if precisely this species is found on the Pacific coast, though Fremont found a small number of trees of a species very near to it, if not the same, in the Sierra Nevada.†

In the middle States a low, rough, and irregular growth of pitch pine covers the sandy and deserted tracts, which sometimes attains a size sufficient for lumber. South of Virginia the true yellow pine, and long-leafed yellow pine, become abundant, attaining a fine growth. This covers a large area of lands on the lower plain of the southern States to Louisiana, most portions of which equal the white pine forests in the clear growth and great size of the trunks.‡ A large tract with a fine growth of yellow pine

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* Lieut. Bryan reports it on the Llano Estacado, lat. 31½° N. long. 101°, and 3000 feet above the sea, near the head of Concho River. At Mount Graham, near the Gila River, long. 108°, Lieut. Parke remarks: "Around the camp there grows an evergreen oak, generally dwarfish, and of but little service except for firewood." The altitude here was 5000 feet. Dr. Bigelow found a "large and beautiful species of evergreen oak, with very large cupules and acorns," at the Cajon Pass of the Sierra Nevada, and it is known to be frequent in that part of California. In Spain evergreen oaks of several species exist over the dry and elevated interior.

† "The forest here has a noble appearance; (altitude 8050 feet) the tall cedar is abundant, its greatest height being 130 feet and circumference 20 feet three or four feet from the ground; and here I see for the first time the white pine, of which there are some magnificent trees. Hemlock spruce is among the timber, occasionally as large as 8 feet in diameter, but in ascending it tapers rapidly to less than one foot at the height of 80 feet. I have not seen any higher than 130 feet, and the slight upper part is frequently broken off by the wind. The white spruce is frequent, and the red pine, (*pinus colorado* of the Mexicans) which constitutes the beautiful forest along the flanks of the Sierra Nevada to the northward is here the principal tree, not attaining a greater height than 140 feet, though with sometimes a diameter of 10. Most of these trees appear to differ slightly from those of the same kind on the other side of the continent."—(Passage of the Sierra Nevada, Expedition of 1843–4.)

‡ Drake describes the celebrated *pine woods* of Alabama as follows: "The prevailing and characteristic forest tree of this plain is the long-leaved pine, which in many parts, as between Pensacola and Mobile, forms a dense and lofty forest almost to the exclusion of every other tree. Straight and destitute of limbs to a great height these pines present to the eye a vast system of intercolumniation, which, seen at night by the running fires that occasionally consume their shed cones and leaves, with the dry

exists in Missouri on the southern slope of the Ozark hills, and portions occur at intervals southward to Red River. A pine tract exists in France similar to these of the southern States,—a sandy plain stretching from Bayonne to Bordeaux—on which the pines (*p. maratima*) are also worked for turpentine in the same manner as those in North Carolina. It is probably the only similar tract in Europe.

In the arid interior the cedar is the most abundant of the evergreens, and it is everywhere small. In New Mexico at the south the pines with edible fruit abound (the *piñon* of the Mexicans, *pinus edulis*) intermingled with the cedars; and the external resemblance of these to the low pines of Italy is quite decided. Crossing the western limit of the desert, the gigantic coniferæ of the Pacific coast and mountains appear; the largest of these is the new *Wellingtonia gigantea*, a "cypress" (*taxodium*) of immense size, specimens of which attain 350 to 400 feet in height, and fifteen to thirty feet in diameter. There is but a single locality of these, a few hundred in number. Next is the redwood (*sequoia sempervirens*), more nearly a cedar, 150 to 300 feet in height, and often ten or twelve feet in diameter. The *pinus Douglassi* approaching the form of the spruce; *p. lambertini*, sugar pine, and the yellow pine, *p. brachyptera*, assist in making up the gigantic forests of the cool and elevated district. The whole country northward, including the splendid forests of the Blue mountains in the interior of Oregon traversed by Fremont at his first journey, is covered at intervals by gigantic growths of some of these species. The cool and equable climates of the Pacific favor these forests beyond all others, and they extend inland only to the districts controlled by the sea influence. The limiting line is very abrupt on the Sierra Nevada, and on the Cascade range north of the Columbia; the eastern slope in both cases suddenly changing these splendid forms to dwarfed cedars. The Blue Mountains are proved to be under the influence of the sea climates to some extent by the presence of the fine spruce and pine forests encountered in crossing from Snake or Lewis river to the Columbia at Walla-Walla.*

In the north here a spruce is found quite similar to the hemlock of the east (*abies canadensis*) and magnificent larches (*pinus larix*) in great abundance in the interior.* The hemlock is remarkable in the eastern States for its strong growth in the more cool and damp localities of the northern States, where it forms a forest even heavier than the largest pines.†

There are several minor resinous evergreens belonging to the cool latitudes and damp climates and soils; the "spruce-fir" of Richardson is mentioned as the outlier of the woodland belt on the north through all British America; next is the black spruce, which is a tree large enough for building purposes in parts of the northern

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grass among which they have fallen, present a striking spectacle. . . . Such are the celebrated *pine woods*, to the protecting influence of which the people of New Orleans and Mobile commit themselves in the yellow fever season." (Drake's Interior Valley.)

Nuttall designates the prevailing forest pine of the south as a long leafed yellow pine, (*pinus palustris*) and he distinguishes it from the yellow pine of Virginia and Canada. The timber of the southern yellow pine is more extensively used in ship-building than any other, and it is equal to the best procured in the Baltic. "The yellow pine of the Central States is coarse grained and inferior." *American Sylva.*

* See Fremont's interesting description of this pine forest in his Expedition of 1843–4.

† Gray names the following leading trees of the eastern forest among the forms entirely absent from the Pacific coast; magnolias, the basswood (*tilia*), the locust and other leguminous trees, all elms, walnuts and hickories (*juglandacea*), all beeches, the hornbeam, and ironwood. The chestnut is represented by one species of *castanea* of Asiatic affinities, and the maples only by one or two small forms, one of which is sub-aquatic. (Amer. Jour. Sci., May, 1857.)

States; the white spruce, the balsam spruce and balsam fir, the white cedar, and the American larch, or tamarack. All these are small and belong to hill points, mountains, and swamps, in the northern parts of the United States; and in British America they make up most of the forest belt described by Richardson as stretching from Lake Superior, the hilly shores of which it fully occupies, along the border between the country capable of cultivation on the southwest and the uninhabitable vicinity of Hudson's Bay and the Arctic Ocean. On the northeast the desolate "Barren Grounds" lie, and the forest of the kind described, with many small deciduous trees, also stretches in sheltered spots to the mouth of Mackenzie's river. At one point in the Alleghanies of North Carolina a sub-alpine growth of balsam fir crowns the summits of a group called the Black Mountains, which are the highest points of the entire Appalachian range. It appears between 5000 and 6000 feet above the sea, occupying a thousand feet of the summits with a dense growth from which the mountains are named.

The range of pine in the southern States, including Missouri, appears to be in accordance with a peculiar American rule which disregards the ordinary climatological limitations. In many parts of Cuba and St. Domingo, and particularly on the southern coasts of Cuba and the Isle of Pines, a large open growth of *pinus occidentalis* is found; in the last two districts associated with mahogany as the second principal portion of the forest. The soil of these tracts is arid and sandy, as in all the plains of the southern States where pine forests prevail. "The interior plain of Mexico is covered with the same class of coniferas if we may rely upon the comparisons made by Bonpland and myself,—and these do not seem to differ even specifically from the *pinus occidentalis* of the Antilles, as described by Schwartz. But these pines, which we find at the level of the sea in Cuba, between 20° and 22° of latitude, and only on its southern side, do not descend lower than 3200 feet above that level upon the Mexican continent, between the parallels of 17½° and 19½°. These anomalies of position are very rare under the torrid zone, and depend probably less on the temperature than on the soil." (Humboldt's Cuba.) Humboldt infers that this pine came from Yucatan, and not from the United States, since none of this species has yet been found in Florida. The identity of soil and character of the forest generally among all these tracts is very obvious, however.

One of the deciduous cypresses, (*c. distychia*) is pre-eminently adapted to the hot and humid localities of the southern States. It begins as far north as Maryland, and occupies all the denser swamps of the entire south, attaining the greatest size in those which are most nearly tropical in heat and humidity. It not only forms large and valuable trunks from which lumber of every sort can be prepared, but it spreads in low arms, like tropical sub-aquatic trees; and in the dank air of those swamps it is covered with the picturesque pendulous moss which forms so conspicuous a distinction of the humid localities.

The shrubs, or sub-forest growths, in many cases afford better definitions than the forest trees, and, as in Europe and Asia, they characterize a large area here. At the tropical border on the south many northern shrubs become considerable trees, marking the distinction only in this way, and not disappearing under the change of conditions. The Elder (*sambucus*) becomes a tree, and the Black willow is equal in size; both are universal shrubs in the humid climates, but the willow only goes to the interior and Pacific. The sassafras tree is very large in the Delta, and only a shrub in Northern New York. The laurels have the entire range also, and change nearly as much, the creeping, tangled laurel of the hills of Canada, becoming a shrub of the largest size "with white blossoms shaped like a lily and a foot in circumference" on the coast of South Carolina. In the last case there may be specific differences, yet with so much identity as to illustrate the point that they are simply modified and not removed by the climatic range.

Over all the eastern districts the usual shrubs of temperate latitudes are distributed. The *vaccineæ* or whortleberries are universal, and they are generally taken

as the equivalent of the heaths of the old world, of which we have none. There are very few Rhododendrons, and these in Virginia and on the highest portion of the Alleghanies in adjoining states, but the Azaleas are almost universal. The species of *Ribes*,—currant and gooseberry, are very numerous, and these increase in abundance to the Pacific. The alders and spireas, with very many others, also extend at least the entire length of the Alleghanies, and the peculiar influence of this range of mountains appears to distribute the various genera of shrubs existing at any one point of it quite generally over the whole.*

The fruit bearing rosacea are as abundant here as in the best climates of the old world, and the various small trees and shrubs of this great family crowd every part of the belt from the lake district northwestward to the Pacific. They are profuse in minor fruits far northward in British America, Richardson finding various forms on the Mackenzie nearly to the Arctic circle. The detail of this distribution on the northern plains, and for so much as is known of the north Pacific coast, must be omitted for want of space.

This natural fruit region of cold climates embraces the Pacific coast as far south as San Francisco, but this exterior line surrounds a large area of quite different characteristics. A portion of the plain of the Missouri is Asiatic in its aridity, and a plateau at the sources of Jefferson's and Madison's Forks is not only arid, but probably also saline and volcanic. The Great Plain of the Columbia is even more dry, and over all these the variable shrubbery of the latitude ceases, and endless fields of Artemisia, with saline and chenopodiaceous shrubs, succeed everywhere. There is no plant of such extensive range and such climatological significance as the artemisia of these plains, (*artemisia tridentata*) which is usually called *sage*. On the borders of this district there are some species of spireæ, the *Purshia tridentata*, and a few intermediate shrubs, but for an immense region bounded by the 100th meridian at the east, the Missouri river on the north, the Columbia (Clark's Fork) through most of its course which lies north of Puget's Sound, and a line crossing the cascades in the latitude of

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* Gray gives the range of some of the common woods and shrubs in a forcible statement of average and extreme positions, which is here condensed as follows; of our 348 woody plants of the average range north and south is 13½° of latitude, and 15 species range over a space from 30° to 40. Of these last, the climatic range is greatest in the Red Cedar, *juniperus virginiana*, which goes from Middle Florida at 26° north to lat. 67°, beyond the Arctic Circle. Two species of Wild Cherry, one of which is a magnificent tree in the forests of New York, and the Amelanchier, Shadbush, or service-berry, have nearly the same range. The trembling poplar (*p. tremuloides*) ranges from 37° to 69° north. Sixty-eight additional species of woody plants range through 20° to 29° of latitude; among the most extreme of which are the red maple, white and red oaks, white elm (*U. Americana*), the elder (*sambucus*), bass-wood, and the wild grape. (*Vitis cordifolia.*) Again, 57 species range through from 15° to 19° of latitude; embracing most of the maples, and a share of all the ferns before named. Finally, fifteen trees have a range of but 6° of latitude, and six of but 4°.

"Of the 1745 phænogamous herbaceous plants of the Flora of the Northern United States, diminished to about 1690 by the exclusion of the Alpine and sub-Alpine species, here left out of view—

843 species, or 50 per cent., range southward to the borders of the Gulf of Mexico.
538, or not quite 32 per cent., extend westward into the Saskatchawan basin, and Labrador.
107 of these reach across the Arctic circle.
24 species, or less than 1½ per cent., range from the Gulf of Mexico to the Arctic circle.
180, or 10¾ per cent., range from the Gulf of Mexico to the Saskatchawan or Labrador.
248 species, or over 14½ per cent., range from the Gulf of Mexico to the Great Lakes or the St. Lawrence.

—"About 115 of our phænogamous species are represented by strict analogues on the western side of the continent."—*American Journal of Science*, May 1857.

the south end of Puget's Sound—for all the area south of this to New Mexico, and to the region of *Cacti* in the desert, which is at about the 36th parallel, the predominating shrub is the artemisia. In saline tracts various salicornias, the Fremontia, and chenopodiaceous shrubs occur, and sometimes these are very abundant, as about Great Salt Lake. Few willows, even, appear in all this region, and no variety of shrubs or trees occurs except on mountains.

South of this desert belt there is a shrub region in Texas and New Mexico which is more variable. It is the eastern extension of the cactus belt more distinctively than anything else, and near the Californian extremity the cacti become huge half-woody trunks, of forty to fifty feet in height. The whole belt differs largely from those before described, and it belongs to the transition zone between temperate and tropical latitudes; like Spain, the Barbary States, and Palestine. Acacias become numerous, and of these Gray cites and describes fourteen species belonging to southern and western Texas. There are many Cassias also and several Mimosas, with other leguminous shrubs described in Wright's collections. (*Plantæ Wrightiana.*) The celebrated Mezquite tree and shrub—as it becomes a shrub on ascending the high plains of western Texas, and from that point to the lower Gila continues such, with a large woody root much used for fuel—characterizes the whole extent of this district. This is a leguminous tree (the *algarobia*, or *prosopis glandulosa*,) associated with the acacias, cassias, and more nearly, perhaps, with the Carob tree (*ceratonia siliqua*) of the south of Europe.

On the Canadian river, and at the passage of the mountain ranges east of the Rio Grande in that latitude, there are some instances of wild fruits, but the number is very small compared to the northern district before described. There is little artemisia in so low a latitude, but various species of compositæ other than this become shrubby, and occur with some chenopodiaceous and rosaceous shrubs. The artemisia so far observed is only on the high plains toward El Paso.

On the south of Texas is the characteristic *chapparal*, which is a dense growth of low, thorny, leguminous shrubs, most abundant near the Rio Grande, yet extending into some parts of Sonora. Its compact thickets, so well known as the obstacle to travel out of the great roads in any part of that country, mark the southern limit of the transition belt we are considering, and occupy an immense space southwest of the Nueces, in all the low country of the Rio Grande.

West of the Rio Grande the number of shrubs diminishes very much, and the cacti become more numerous, the change being toward a more desert like vegetation. This continues and culminates on the lower Gila and the Mohahve rivers, where the cactus growths become gigantic, and there are few shrubs; but at the passage of the Sierra Nevada an abrupt change to milder climates and more variable forms occurs. The mesquite and sage continue abundant over all the interior, and even beyond the Sierra they occur in some places, showing that the climate does not forbid their growth there, though it is not particularly favorable. Toward San Francisco there is a share of desert shrubs mingled with those which grow in cooler air, and the fruit-bearing trees again become abundant.*

Next to forests as native climatological landmarks are the native grasses, which will require but a single remark here. Their range is as wide as the forest range, since like that they go from tropical to arctic forms. In the rich alluvions of the south and of the Mississippi valley a most remarkable grass exists, which forms a half forest of itself,—the native cane, *miegia*, or *arundo gigantea*. The cane brakes of

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* On the Pacific coast there are no indigenous grape-vines, except one in California; and the following shrubs are marked as absent by Gray in the paper before quoted;—the shrubby as well as the tree forms of the thorny leguminosæ; the locust and mesquite, so abundant in Texas; the vaccineæ and associates (huckleberries and blueberries), with others less conspicuous.

the Gulf States are often twenty feet or more in height, and absolutely impenetrable as they stand. All the timbered alluvions from Florida to the Colorado of Texas are more or less occupied by this gigautic grass, and in proof of the peculiar extension of tropical features northward it has grown abundantly on the Ohio, Wabash, and Big Sandy rivers west of the Alleghanies, and on the Potomac at Washington. Drake and others mention its abundance at the points named in the west, and on the Cumberland, Tennessee, and other rivers tributary to the Mississippi.* It was formerly abundant in South Carolina in like localities. Drayton says, "at the first settlement of South Carolina the valleys of the middle and upper country had a plentiful growth of cane, but since the whites have spread themselves over the country with their herds of cattle they have nearly extirpated it."† It grew iu the marshes bordering the Potomac at Washington as recently as the date of the foundation of that city at least, a point quite as far north as the limits cited by Drake on the Kanawha and Big Sandy rivers of the Ohio valley.‡

There are several representatives of this class of free growing succulent plants marking the same climatological definitions, of which the *yucca* or *Spanish bayonet*, is the principal. The palms are variable in respect to the degree of humidity they require, however, and none of them may be taken as a definition in this respect. The palms and yuccas rank equally with trees and with succulent herbaceous forms, and they are significant of a close approach to tropical climates, though often intruded into the transition belt. The yucca becomes a tree thirty feet in height in southern New Mexico, the adjaceut parts of Mexico, and in California east of the mountains. It was found at the eastern foot of the Sierra Nevada in abundance by Capt. Whipple, who mentions "beautiful yucca trees thirty feet in height," and speaks of "passing through groves of yuccas as beautiful as the cocoanut and palms of southern latitudes." (*Railroad Survey of a Route to the Pacific near the 35th parallel.*) Bartlett found it quite abundant at many points along the boundary and in Mexico, where it is also twenty-five to thirty feet in height, and with an edible fruit. (*Bartlett's Pers. Narrative.*)

Most of the yuccas are herbaceous, however, and they are abundant in the south Atlantic States, with one species, *yucca angustifolia*, two or three feet high in Missouri, and another in Virginia of less size. Pursh names seven species belonging east of the Mississippi, of which one, in the Carolinas, is ten feet in height, and two bear the open air in the warmer parts of New York, though none are native beyond Virginia. This is more nearly than any other form the associate of the palms.

The sugar cane and its associates, with millet, Indian corn, &c., are exotics only by a narrow margin of differences, and though probably of tropical origin, they are now temperate latitude forms. A Chinese *Sorghum* recently introduced is said to possess the saccharine qualities of the sugar cane, with a period of growth and a profuse seeding perfectly adapted to the border of the temperate latitudes. It is a peculiarity of American climatological geography of plants that these forms, which originate in *humid* tropical heats, here possess a rauge into an arid atmosphere, if the temperature does not fail.

In passing from these to the natives of arid districts, we find the great American class of Cacti, standing in the place of the European and African Euphorbias—thick, succulent, fleshy-leaved inhabitauts of deserts, or of districts which are too arid to

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* "The cane (*arundo gigantea*) seems not at any time to have grown north of the Ohio in this State (Ohio). On the Wabash it is frequently seen, but seldom pushes itself north of the 39th parallel. In the fertile parts of Kentucky this plant, 25 years ago, formed impenetrable and extensive brakes, which have long since been devoured by cattle, and at present not a single stalk can be found. *Drake's Cincinnati*, 1815, p. 83.

† *View of South Carolina*, p. 62.

‡ On the authority of Col. Force, of Washington, and others.

be successfully cultivated. They begin at intervals in high latitudes, but do not attain a great importance as characterizing vegetation until the great sage belt is passed over, or at about the 36th parallel. In this latitude the best defined district exists beyond the Rio Grande, where the *cereus giganteus* is the leading form, and itself a tree in size.

The great unwooded plains are mainly grass covered, and they have a single ground of distinction in the preponderance of grasses adapted to dry climates. They are expressively *prairies*, and though Murray and others have divided them into several minor districts, according to the prevalence of various flowering plants, there seems no climatological reason for doing so. If so divided the asters and other compositæ would distinguish all the upper plains; and the various onagracea (primroses particularly) with herbaceous leguminosæ, the lower or southern plains east of the Rocky mountains. West of the mountains Claytonias and Lupines are most abundant at the north, and papaveracea at the south, in New Mexico and California. The grasses are far more definite than these, however, and they mark two or three divisions,—first the wet prairies, and those of retentive soils at the north and east of the prairie region; next the dry central plains, where no wood exists and the Buffalo grass (*sesleria*) is prevalent; and last the prairie and sand districts most nearly deserts, where the large grama and the bunch grass prevail. There might be still another named in California, where wild oats and the higher gramineous forms are native.

The first of these divisions belongs to the intrusion of plains and prairies where wood will grow, and among woodlands, as in most of the country east of the 98th meridian in the United States, and over most of British America farther west. The next is an entirely unwooded belt, too dry for deciduous trees, if not incapable of producing forests for other reasons. The third is a rough variable district, with sands, saline tracts, shrubs and stunted woods only. The celebrated "bunch grass" is apparently made up of various species of *festuca*, some of which are adapted to very cool climates, and some to the most intensely hot of this continent. The wild oats and some associated species again come upon cultivable lands, and find their climatological requirement in the extremely contrasted wet and dry seasons.

The wild grape-vine is most extensive in its range in the American climate, and a significant climatological fact. It is universal to as high a latitude as Indian corn will grow, and nearly coincident in position at the limiting lines everywhere. It is not the equivalent of the European grape however, since the limit of the cultivated vines of Europe falls far short of the limit of Indian corn, and the American native species or varieties are peculiarly hardy under the variable temperature and variable humidity here. A high summer heat is essential to them, with the peculiar fulness of luxuriant capacity, if it may so be termed, which belongs to the eastern United States. In Massachusetts and the warmer localities of most parts of New England, Canada, Michigan and Wisconsin, the native grape grows freely, and from the northern limit of 65° mean temperature for the summer it increases in value and delicacy until at the mean of 75° rich and perfect fruits are among native varieties. The single fact of the almost universal presence of the wild grape-vine in the eastern United States is of high climatological significance, and in the central States near the 38th and 40th parallels they form stems of immense length, covering the highest trees, and indicating the very best capacity for the plant, as such, though not affording the delicacy of fruit found in Europe. In valleys at the north shore of Lake Superior it is also abundant, and in many places on the British American plains of the interior.

The preceding enumeration of characteristic plants is far from being exhaustive of those having decisive climatological distinctions, but the chief native forms, or those most conspicuous as representatives, could alone be enumerated in this general purpose. The geography of native and cultivated growths on this continent remains to be written, and it can be done only in connection with accurate climatological distinctions.

XIV. CLIMATOLOGICAL RANGE OF CULTIVATED STAPLES OF TROPICAL OR SEMI-TROPICAL ORIGIN.

THE most important fact in the climatological capacity of the United States is the great success of staples of tropical origin, or of those adapted to the transition climates, whether they originate there or in the tropics. The agriculture of the southern States is always very largely, and for many large districts, exclusively made up of them; and no part of the country east of the Rocky Mountains fails to produce Indian corn, tobacco, and grapes to some extent, the first two as extremely successful crops. The forests show something of this capacity in the presence of palms, magnolias, &c., which in some form go to the lake district, and the native cane and succulent grasses still more decidedly evince the capacity; yet the range of extremes of temperature is such that native growths liable to injury from frost are restricted to a very much lower latitude than cultivated staples of a similar character.

The basis of this capacity is the high curve of heat and moisture for the summer, and the fact that the measures of heat and of rain are almost or quite tropical, for a period varying in duration from one to five months, in the range from Quebec to the coast of the Gulf. The elasticity of these peculiar staples is such that they adapt themselves to this variable period if the maximum degree of heat is attained for only a short succession of days; Indian corn, the most important of the whole, displaying an extraordinary variation in its period of growth, and being reduced to less than sixty days at the Red River valley, latitude 50° north. The statistics of this curvature in the line of temperature march for the summer months are singular in comparison with the succession of the same months in Europe, and it may roughly be said that for the country east of the Rocky mountains it is the attainment of a uniform height at midsummer by steps differing as the winter reduction of temperature differs; at New Orleans rising from 55° for a winter month, at St. Louis from 33°, and at Fort Snelling from 15°, to the same position for July. The mean for July is in fact but two degrees lower at St. Louis than at New Orleans, and

but five degrees lower at Fort Snelling than at St. Louis; the whole difference of latitude being 15°, and the reduction of temperature less than half a degree for one of latitude in summer, and more than five times as great in winter. The average measure of the step from March to June in the eastern States is ten degrees on the mean of each month, but this becomes irregular at St. Louis, where the difference is greater for the first month, or from March to April, and a little less for the next. At Fort Snelling the first step is 15°, and the second 13°, the last being 10°. At New Orleans the three months which bring the winter temperature up to that of summer differ six degrees east, and this is nearly the average of differences at London and Paris. The vigor given to vegetation in cold climates by the rapid increase of temperature, apparently as a single phenomenon, is well known, and the peculiarity of the climate here is that this great stimulus is thrown upon tropical forms, producing the highest measure of productiveness for this reason.

The first cultivated staple in value and in the directness of its climatological relations is Indian corn; next are tobacco, cotton, sugar-cane, rice, indigo, and hemp; though the last is of doubtful success here in the tropical form, or in case of the Sisal hemp. The common hemp belongs to temperate latitudes, and the various succulent fibrous-leaved plants from which the other varieties are derived will undoubtedly grow freely in various parts of the Gulf coast, though now little cultivated. The vine, and several fruits belong in the same connection also; oranges, olives, figs, and pomegranates of full tropical associations, and the peach as the most important native of the transition zone. To these the annual vines, as they are here called, melons, pumpkins, and others, add a very decisive proof of the tropical heat of the American summer, and form a distinction where even the olive and orange fail. The country near Fort Snelling abounds in these more decisively than any part of the European shore of the Mediterranean, where even the orange and olive come to perfection, and find a safe winter climate. The high brief heat which these require is as certain here at Fort Snelling and in Canada, as at Naples and in Syria. When the native districts of the various species of *cucurbitacea* are called to mind, all of which are in India or Africa, the growth of the melon and pumpkin as field crops in the astonishing profusion they often exhibit north of Lake Ontario, and on the plains of the upper Mississippi and Missouri, furnishes a striking item in proof of the contrast with Europe in capacity to develop plants of tropical origin.

This highly stimulating increase of heat characterizes all the native vegetation, and the cultivation particularly, here, while the degree is high and constant enough to make the production singularly rich.

Sugar is the most abundant product, and it belongs to many variable vegetable forms. The stem or stalk of Indian corn abounds in it nearly as much as that of sugar cane, and if it could be separated and clarified readily a heavy growth of corn would yield nearly as much as a canefield of the same area. Stems of grasses, and all graminaceous plants show the same tendency, and there is the greatest abundance of sugar in melons, and other cucurbitaceous fruits. On the plains in the Mississippi valley this tendency to development of saccharine matter is more striking than elsewhere, and it cannot fail to be noticed in almost every vegetable cultivated for any nutritive use. It is an associate of the rich curve of summer development there, as it may be called, which has only a higher degree than in the Atlantic States in the same latitude, and it constitutes a decisive distinction from climates where the leading elements of vegetable nutrition put on other forms, and those of a less complete character.

The peculiar staples which attain the highest perfection in the United States are moulded by these general features, and not more by the tropical measure of summer heat than by the sub-arctic cold of winter. They are of sudden growth, exuberant and profuse in every respect. The forest trees come suddenly in leaf, and all that belongs to foliaceous growth is equally sudden and luxuriant. The nutritive elements are developed next on the same scale of profusion, and the predominant form of these is as decidedly saccharine as in the tropics. All that belongs to the ripening stage is similar, the essential oils, and the concentrated elements of seeds and fruits whether nutritive or aromatic. The interior of the eastern continent, in the transition climates near the Mediterranean, affords the highest development of these ripened forms, and one much beyond that of the United States it is true, but here all products blend in a climate developing great profusion first, and a tendency to high perfection in all the ripening processes, which a little care might make scarcely less rich in its results than the best districts of the Mediterranean. The most favorable close of summer and autumn belonging to our variable seasons has scarcely a parallel in its fruitfulness even in any of the transition climates of the old world.

The leading staple belonging to this distinctive climate is maize or Indian corn, and the succulent grasses and canes belonging to the same family have necessarily been frequently alluded to in expressing the result in the various forms it presents through the different departments of practical climatology. This plant is itself peculiarly elastic in its adaptation to variable periods of growth, and the fact that it may be compressed within a very limited number of days permits it to occupy every district in which the summer temperature reaches a

certain point, however brief the duration of the heat. Thus it grows and ripens in the Red River valley at 50° north latitude, though the summer is very short, and the yearly mean temperature less than that of the British provinces of the Atlantic coast, where it will not grow because the summer heat is insufficient. The British Islands still more strikingly show how, with a high winter and annual temperature, a deficiency of two degrees on the mean of a summer month may preclude its cultivation altogether.

As tropical plants the cane and corn could hardly be supposed to permit a shortening of their period by frost in any case, but in the climate of the Mississippi valley the high heat of midsummer and its sharp curve among the months brings the period of growth in the case of Indian corn down to two and a half months at the 50th parallel, a most extraordinary transformation of its natural habits and associations. The period is precisely proportioned to the abruptness of the temperature curve, and that this is a natural, though new relation of this class of plants to climatic peculiarities, is shown by the presence of the native cane (*miegia*) nearly at the 40th parallel, and by the extraordinary growth of the sugar cane itself in the summer to the 42d and 43d parallels near the Mississippi.

The extreme limits of Indian corn northward are defined by the isothermal of 67° for July, and it may go a little beyond 65° for the summer; one month, however, being required at a higher mean than this. From the eastern coast the limit may be traced through some parts of the valley of the St. John's river, New Brunswick, though the isothermal of 65° scarcely rises so high; it goes into the valley of the St. Lawrence to Quebec; reappears in the Saguenay valley, and at intervals along the northern shores of the great lakes through their whole extent. Though shunning the highlands south of Lake Superior it goes north from the north shore of the lake northwestward to Lake Winnipeg at the meridian of Red River, continuing northwestward to the north branch of the Saskatchawan, if not to Athabasca river. At this point it abruptly returns southward nearly to Santa Fé across thirteen degrees of latitude to avoid the great plateau of the Rocky Mountains. Beyond this plateau, though the isothermal of 65° returns again to the plains of the Columbia, the adaptation to this staple is very irregular, and in its arid and elevated districts a higher mean is required to permit a perfect growth. In many low areas and limited localities this excess of heat exists, and this staple may be safely grown, but in others local extremes destroy it. On the Pacific coast it fails wholly, but in the interior valleys of the Sacramento and San Joaquin the great excess of heat brings it in, almost in its tropical forms, where it grows at all.

The range which is of most interest in this climatological illustration is that found at the east of the Rocky mountains, and from the district defined by the line above given, there are several local areas of highlands to be taken. In the New England States all above a thousand feet elevation may be defined as excepted, embracing considerable tracts in the northern States, Maine, New Hampshire and Vermont. In New York there is a large area north of Albany and Utica on which the same limitation in height may be said to decide against it, and in the elevated plateau of southern New York, stretching from the Hudson nearly to Lake Erie, an altitude of eighteen hundred feet cuts it off. There are small tracts only at this altitude, but they are scattered from the Berkshire hills to the Alleghanies of northwestern Pennsylvania.

There are a few elevated localities in northern Pennsylvania too high to permit its growth, but generally the cultivable lands at two thousand feet elevation, where there are such south of the 41st parallel, permit a very free growth, and on the Alleghanies in Virginia the same varieties cultivated in the low country appear equally successful in the most elevated fields.

From the tropical latitudes where it is native, and of course has no limitation, to the lines here indicated at the north, this range is certainly one of the most remarkable of the phenomena of vegetation when the habit of the plant and the positive changes of climate are considered. In this sense of scientific interest it suggests new questions in regard to the acclimation of many plants of tropical origin, and new views of the modifications which climate alone may effect on all that we cultivate. It is possible that acclimation under these conditions may present transformations not less extraordinary with many other species, if pursued as an art with persistence enough to develop varieties differing as much among themselves as those of Indian corn differ.

The limit of profitable cultivation of this staple is a practical question which belongs to this consideration, and it is somewhat singular that what may be designated as its decided success is so nearly coincident with the extremes of its possible limits. It is still more extraordinary that the district of maximum production lies so far north of the native latitudes, and really near the northern extreme of its position. In New York, the southern New England States, and Ohio, or from the 42d to the 43d parallels, the maximum of production of this staple is attained, and this maximum is of the entire sum of its growth,—leaf, nutritive matter in the stem, and grain. Though the stem is of less size than farther south there is a greater weight of it grown on equal areas, and the grain is in equal excess. A rich spot

of land will show, in a favorable season, in these northern districts where the summer mean temperature is not above 68°, four or five times the quantity produced at the south where the mean is above 80°.* In part this may be due to soil and to productive varieties, but it is mainly due to the summer curve of temperature,—the hasty growth, the excess of heat while it lasts, and the hastened ripening period. Continued heat without this curvature prolongs the growth in a way to modify the species in the direction of the original form of a succulent tropical grass, and it there becomes a cane more nearly than in the colder latitudes.

The existence of this maximum of productive capacity in the cooler districts is of greater practical interest perhaps to the southern than the northern districts, since it shows that with the increase of value in southern lands, and the introduction of staples of peculiar adaptation and of the highest value, the growth of this grain may profitably be transferred to northern localities. To a certain limit of latitude cotton and the cane, with perhaps the fibrous tropical plants and others, may occupy the cultivated territory to greater profit than any of the grains. The sugar-cane is the natural successor of Indian corn in semi-tropical districts; its analogies of growth and its development of saccharine matter are nearly the same, and with the greater heat and humidity of some portions of the United States the product of grain certainly falls off, and the corn plant loses its extraordinary power of expansion and excessive production. It is highly probable that the introduction of the best possible staples in our warmer districts will make the transfer of maize northward possible and desirable, and when transferred above the 33d parallel, if this should be done, there will still be an immense area over which it is, under proper circum-

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* There are well authenticated cases of one hundred and twenty to one hundred and thirty bushels of the grain produced by an acre in this cultivation, with a mass of saccharine stems and of nutritive leaves in equal profusion, and it is doubtful if anything equal to this in nutritive value can be found among all the products of the temperate or transition zones. This is, also, the easily obtained growth of high temperate latitudes, as they may be called here, at the 43d parallel, and on soils covered originally with simple upland forests.

A number of instances cited by Coleman, (15th Volume American Farmer) and by Ruffin (Farmer's Register, vol. 2) may be named as having been accepted as correct by the first author, and said to be in all cases derived from verified statements presented for premiums. Fifteen cases in Massachusetts are named, occurring from 1820 to 1831, and varying from 110 to 142 bushels per acre. Others are given for Madison county, New York, in 1821 and 1822, where the product varied from 161 to 170 and 172 bushels per acre. Several for other points in New York have 120 to 140 bushels, and seven certified cases in Pennsylvania, mainly in Washington county, are taken from the Memoirs of the Pennsylvania Agricultural Society, ranging from 118 to 136 bushels per acre.

stances, the most prolific and profitable crop possible regarded as a source of nutritive supply.

The western half of the continent is a different field for this plant, and it is very irregularly adapted to it. There does not appear to be much change on the plains, though the upper Platte, and the Missouri river at the *coteaus*, traverse a country too arid in summer, it is said, to produce corn. At the foot of the Rocky mountains it may be grown however, both at Fort Benton, near the sources of the Missouri, Fort Laramie on the Platte, 4500 feet above the sea; Bent's Fort of the Arkansas, and Las Vegas, at the source of the Pecos, and at the summit of the Llano Estacado. The last point is 6000 feet above the sea, with a summer heat still sufficient to perfect any plant belonging to the latitude. None of these points exhibit peculiarities widely different from those belonging to the plains at lower altitudes, and the recognized mountain influences generally, especially in regard to extremes of temperature, are but partially felt.

Beyond this line, however, very favorable localities only permit any successful cultivation of Indian corn; and in the lower latitudes but greater altitudes of the Salt Lake Basin the same conditions exist. Here the mountain influence predominates largely, and though the fitful heats of the warm months tend to a rapid growth while they last, they are very different in character from the brief but hot summer of the east and north.

Upper New Mexico has also a mountain climate, but at the latitude of Santa Fe important modifications occur in softening the temperature changes, and Indian corn not only succeeds in the valleys, but it goes successfully to the upper plains and plateaus at the height of seven thousand feet. At Zuñi, west of the Rio Grande, and at Las Vegas at the east, both not far from the 35th parallel, there seems no climatological check to the growth of this staple, and it is, as almost everywhere else in the warmer parts of North America, the most successful and productive crop. In the Colorado valley the measure of heat is excessive, but it has little cultivable surface, and the limitations, if any, are on the side of too great heat.

In California again the contrasts are extreme; at the south the tropical equability exists, with a soft rather than prolific character of climate. The vine and fruits are better fitted to it than corn and the cane. In the interior valleys of San Joaquin and Sacramento the temperature is excessive and the growth prolific, but the absence of rains again makes an exception against the succulent growths and in favor of grains and fruits. Near the coast a singular depression of temperature cuts off Indian corn altogether, with all its associated forms. The whole coast, from near Point Conception below the

35th parallel, a point some distance below Monterey, through the entire extent northward—the country exposed fully to the influence of the Pacific—has a temperature much too low in summer for the growth of any plants of this succulent class. There are scattered valleys of partial adaptation to it at various points in California and Oregon, of which, out of the Sacramento valley, that of the Willamette river in lower Oregon is perhaps the principal, but none of these deserve comparison with the singularly productive areas of the eastern States. The contrast these western districts present to one accustomed to the prolific production in the Atlantic States enforces, more than any description can do, the view of climatological capacity and advantage which belongs to the present subject.

To illustrate the differences of climate briefly referred to in this connection, the following observations in the Interior and Western districts may be cited from the imperfect statistics now available for that purpose. Perhaps they represent the climatological features with as much accuracy, however, as observatory records usually do, since the external temperatures, affected sometimes by refrigeration and sometimes by reflected heat, are the real temperatures to which vegetation is exposed. Those taken to represent the fixed averages of temperature alone, often fail to give these desirable extremes.

Lowest Temperatures in the Interior.

		Mch.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.
Norway House, Brit. Am., lat. 54° (mean of 7 yrs.)		—25°	—4°	16°	32°	47°	42°	27°	5°
Pembina, Red River Valley,	1852	..	8	..	50	54	54	..	..
Fort Ripley, Minnesota,	1850	—20	2	24	35	46	42	22	18
" "	1852	—16	2	28	34	38	36	37	20
" "	1853	—16	18	29	33	43	42	32	4
Fort Leavenworth, Kansas,	1850	9	28	32	55	60	53	49	27
" "	1851	22	25	31	48	59	61	43	25
" "	1852	16	27	38	44	58	58	39	32
" "	1853	12	33	38	56	58	49	44	22
Fort Kearny, Nebraska,	1850	9	21	26	49	54	47	40	14
" "	1851	..	24	28	48	54	46	33	16
" "	1852	0	13	32	44	55	54	27	20
" "	1853	—1	29	30	53	50	37	36	12
Fort Laramie, Nebraska,	1851	15	15	30	42	53	56	47	20
" "	1852	—2	14	34	47	55	53	28	21
" "	1853	9	32	33	49	59	55	36	20
Santa Fe, New Mexico,	1851	..	20	34	39	50	45	41	..
" "	1853	16	29	37	40	54	53	46	..
" "	1854	19	29	36	45	55	54	45	30

Lowest Temperatures near the Pacific.

		Mch.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.
Fort Yuma, Colorado Valley,	1853	40	52	52	61	76	76	69	50
" "	1854	37	46	46	59	77	77	68	52
San Diego	1850	39	45	50	56	58	62	51	50
"	1852	36	40	44	58	60	62	49	45
"	1853	38	45	45	56	61	56	53	46
San Francisco (Mil. Post),	1851	34	42	45	49	47	50	50	47
" "	1852	..	..	..	..	55	50	47	46
" "	1853	39	43	46	49	51	51	51	49
" "	1854	39	45	43	49	50	50	49	49

		Mch.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.
		°	°	°	°	°	°	°	°
Benicia,	1851 . . .	38	43	50	52	51	53	51	52
"	1852 . . .	39	..	40	53	54	55	50	48
"	1853 . . .	34	42	46	52	50	50	52	49
Fort Miller, San Joaquin Valley,	1852 . . .	29	38	41	68	..	55	50	41
" "	1853 . . .	34	40	50	51	59	54	50	45
" "	1854 . . .	33	45	46	53	63	..	54	46
Fort Reading, Upper Sacramento Valley,	1852 . . .	..	36	..	54	53	56	39	35
" "	1853 . . .	29	39	46	51	56	55	51	40
" "	1854 . . .	33	40	44	54	61	51	52	46
Astoria, Oregon,	1851 . . .	32	42	46	50	54	54	48	..
Fort Vancouver, Oregon,	1853 . . .	21	33	40	47	50	43	42	28
" "	1854 . . .	34	36	44	46	50	52	50	..
Fort Dalles, "	1853 . . .	22	33	36	43	46	47	46	27
" "	1854 . . .	27	32	39	41	42	50	45	26

These statistics do not cover all the ground it would be desirable to embrace in this especial illustration, since they do not sufficiently distinguish between the coast, where corn may not be grown at all, and the interior where it attains the highest perfection; but they give some valuable facts bearing on the question of adaptation. The short summer of the higher plains and of upper New Mexico is particularly shown, and the slight changes in the lowest temperatures of the succession of months at San Francisco brings in striking relief the importance of the daily and monthly curve of excess of heat to this staple.

An expressive mode of indicating the great range of Indian corn in the United States may be employed in the reference to extreme points on the several meridians from the Atlantic coast westward, and though there are no natural limits at the south, the measures applied to the continents have some significance. At the meridians terminating in New Brunswick and at Quebec there is but little space in latitude, but at 80° west there are 21° of latitude, 25° to 46° north, the whole extent of which is favorable to this staple in the highest degree. The indentation of the Gulf of Mexico shortens the space by five degrees of latitude nearly to the 97th meridian, where there are 28° of latitude north of the tropics, or the entire area south of the 51st parallel. There is here a wide band stretching to the foot of the Rocky Mountains at the west, and from the 51st parallel southward to the tropics, which is everywhere adapted in climate to this most productive plant. West of this belt the distribution is irregular, but the northerly bend of the Columbia river affords localities nearly as favorable as any among the mountains southward to the 35th parallel. At 120° west longitude and westward it does not appear on the Pacific ooast at all, though that meridian traverses some valleys which permit its growth.

A brief reference to the European range will show the measure of contrast between the two continents in this respect. Africa is so entirely tropical as to give little place for the cultivation of Indian corn, though it has been introduced in the States bordering the Mediterranean. In Europe, Spain, the south of France, Italy, the valleys of Austria, Hungary, and Turkey, with the islands of the Mediterranean, comprise its range. This is but a narrow belt, and its climatological limit is so near that the vine goes fully as far under the equable conditions which prevail. The single element of greater heat for one month of the summer is wanting, and so precise and imperative is the requirement in this respect that no effort seems likely to adapt Indian corn to the larger areas of central Europe, or to the British Islands.

The limiting points in temperature for the United States may be taken from the temperature tables in the form of very complete series; Albion Mines, Nova Scotia; Houlton, Maine; Quebec, Mackinac, Fort Wilkins and Fort Ripley being the most deoided or well defined points of limitation. On the plains west of Lake Superior the

point of limitation is much higher, and posts on the upper Saskatchawan would be required to give measures like those just named.

CLIMATIC RANGE OF THE SUGAR CANE.

The cane is more nearly associated with Indian corn in the general character of its climatological requirement than any other staple; differing in this respect only in degree—each condition being required in a similar curve of excess, and of tropical proportions. The cane nowhere goes so far beyond the tropics as in the United States, and how far it may be modified after the manner of Indian corn is yet a question. In the southern part of the United States the great degree of heat which prevails is quite equal to the natural requirement of the plant, and its extension is only restricted by the cold extremes of winter. If it were possible to preserve the root uninjured through the winter, the summer heat would be sufficient probably to the 38th parallel, and the other conditions of abundant rains and a humid atmosphere, if they are also essential, would still be on a scale sufficiently ample in the average of years.

The area now occupied by the cane is quite limited, and in severe years, as in 1852 and 1856, it seems likely to be much farther restricted with the varieties now cultivated. These require a winter free from severe frosts, and an almost tropically equable season throughout the year, but there are many reasons for the opinion that it may be adapted to a curve of temperature among the months, as Indian corn has been, and that thus the root may be protected in a dormant state through any months in which the soil is not absolutely frozen. All the varieties hitherto introduced have been taken from full tropical climates, and that these should deteriorate in severe seasons is not more strange than that Indian corn transferred abruptly from Georgia to New York should fail to ripen. A period of years, and patience in originating varieties, is known to be necessary in the parallel cited, and it is without doubt an analogous process to acclimate the cane.

In several cases the district has been temporarily extended with eminent success for the time, and the cane is reported to have been well ripened as high as at Holly springs, Mississippi, near the 35th parallel.* It has frequently exhibited a tendency to a shortening of its period, and by comparison of the actual periods in Louisiana and at the tropical coasts and islands, it may be seen that the period is already much shortened in the United States. Boussingault gives some statistics of the period of growth in South American climates,

* Article on "Extension of the Sugar Region" in DeBow's Review, March, 1853.

the substance of which is that in the tropical districts having a rainy summer and consequent low temperatures during those months, destroying the curve among the months which belongs to most tropical districts, the period is the most extended, reaching sixteen months. As stated by Boussingault (from Codazzi), the cause of the shortened period does not appear, since he gives only the mean temperatures for the year. The citations are from points in Venezuela, and they assign a period of eleven months to districts having a mean temperature of 82° ; twelve months where the temperature is 78°; fourteen months at 74°; and sixteen months at 67°.* In Louisiana it cannot exceed ten months, yet the mean annual temperature is not above 68°. On leaving the full tropical latitudes the period depends upon the curvature of mean monthly temperatures, and as far as it will go at all, it may be expected to follow the law of the shortened period of growth of Indian corn. The facts of the period of growth in the transition climates near the Mediterranean and in Asia are too difficult of access to use in the present case, but it is clear that the results there presented would be better guides than those derived from the islands of the Gulf of Mexico. The efforts now making to supply more hardy varieties, and such as may endure the extremes of the climate here, may be aided by the comparison of periods of growth, as much as by the facts of ample and perfect growth of any variety in the district from which it is taken—the strongest form, if it has the requirement of fourteen or sixteen months for its growth, must become enfeebled when it is cut down to ten or eleven months, and its permanent cultivation must become impossible.

The following table gives the mean monthly temperatures of districts to which the cane may possibly be extended, and it also represents the cotton district, though this is of course a wider area than that adapted to the sugar cane.

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* "In Venezuela where the mean temperature is 82° the cane ripens in 11 months; where the mean is 78° twelve months are required; where 74°, 14 months, and where 67°, 16 months." Codazzi's Geog. of Venezuela, p. 141.

Mean Temperatures of the Cane and Cotton Districts of the United States, with some Foreign Comparisons.

PLACES.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Sum.	Aut.	Wint.	Year.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Key West	70.0	70.7	73.8	76.3	80.2	82.1	82.3	83.5	82.5	79.1	75.6	72.8	76.7	83.0	79.1	71.2	77.5
Cedar Keys . . .	53.9	59.7	67.3	68.7	75.8	78.6	80.5	80.7	78.7	73.1	64.4	59.8	70.6	80.0	72.1	57.8	70.1
St. Augustine . .	55.9	58.7	62.4	68.0	71.8	78.2	80.0	80.1	78.1	70.9	63.9	56.0	67.4	79.4	71.0	56.8	68.7
Savannah	52.6	54.7	60.0	68.4	74.8	79.4	81.3	80.5	76.9	67.2	58 3	52.2	67.7	80.4	67.5	53.0	67.2
Mobile	56.4	57.4	65.6	70.0	76.3	82.2	82.4	82.7	78.9	70.0	61 5	55.5	70.7	82.4	70.1	56.4	69.9
Pensacola	56.2	57.8	64.5	68.6	76.5	80.7	84.9	83.6	78.9	71.0	61.3	57.8	69.9	83.0	70.4	57.3	70.1
New Orleans . . .	54.8	54.4	61.5	67.6	74.0	78.6	80.4	79.6	77.1	69.1	57.5	56.2	67.7	79.5	67.9	55.2	67.5
Galveston	48.1	58.0	63.5	70.0	78.7	80.7	83.0	83.3	78.3	73.1	60.2	55.6	71.0	82.5	70.2	53.8	69.4
Brownsville . . .	59.5	66.9	69.4	74.5	78.9	80.8	83.3	84.6	80.4	73.9	66.9	60.8	74.3	82.9	73.7	62.4	73.3
San Antonio . . .	52.7	57.8	65.5	69.7	76.4	80.5	82.3	83.8	79.9	72.2	62.2	52.1	70.5	82.2	71.4	54.2	69.6
Fort Jesup . . .	50.5	52.3	59.3	67.4	73.7	80.3	82.3	81.3	76.1	66.2	56 7	50.3	66.8	81.3	66.3	51.0	66.4
Natchez	51.2	52.9	60.5	70.2	74.5	80.8	82.2	80.9	76.9	65.9	57.1	50.2	68.5	81.3	66.6	51.4	66.9
Fort Washita . .	44.7	47.9	52.9	63.5	70.7	76.5	81.3	81.0	75.1	63.2	51.6	42.8	62.4	79.6	63.3	45.1	62.6
Vicksburg . . .	47.8	52.7	63.3	63.7	73.0	77.7	78.7	78.7	74.1	65.4	54.5	50.4	66.7	78.4	64.7	50.3	65.0
Memphis	41.7	45.9	55.3	59.0	68.9	75.8	79.9	78.5	72.5	58.4	53.3	40.2	61.1	78.1	61.4	42.6	60.8
Erie	45.4	51.4	58.9	62.9	73.9	78.2	80.5	80.5	75.3	64.8	53.2	47.2	65.2	79.7	64.4	51.3	65.2
Perry	39.8	55.1	63.2	62.9	74.1	78.2	82.3	78.8	74.8	67.6	53 3	50.9	66.2	79.8	65.3	48.6	65.1
St. John's, Berkeley	49.1	53.6	57.5	62.4	70.2	74.8	78.8	77.9	73.1	64.1	55.2	52.1	63.4	77.2	64.1	51.6	64.0
Havana	70.0	71.9	75.7	79.0	82.5	83.1	83.3	83.8	82.0	79.5	75.5	71.7	79.1	83.4	79.0	71.2	78.2
Kingston	75.7	76.0	76.0	78.1	80.2	80.6	81.6	81.0	80.7	79.8	78.7	76.4	78.1	81.1	79.7	76.1	78.7
Barbadoes . . .	78.0	78.0	79.1	78.2	79 6	78.1	79.0	78.5	82 1	82.2	81.8	79.3	79.2	78.5	82.1	78.5	79.5
Madeira	60.2	61.1	63.4	65.4	67.9	69.4	71.7	72.8	72.1	69.5	65.4	64.2	65.6	71 3	69.0	65.8	67.9
Catania	49.3	54.3	56.0	61.0	71.6	78.9	86.5	88.2	78.6	69.9	59.7	54.9	52.8	62.8	84.6	69.4	67.5
Alexandria . . .	57.3	57.8	62.1	66.9	70.2	76.2	78.5	80.3	78.1	74.8	68.4	60.4	66.4	78.3	73.8	58.5	69.3
Calcutta	69.4	74.2	82.3	87.1	87.2	85.1	84.2	83.6	84.0	82.0	75.7	69.2	85.5	84.3	80.6	70.9	80.3

The sources of these observations may be found by reference to the general temperature tables, except the following; Barbadoes, one year's observations by Young; Catania, 3 years from Dove.

It will be seen that the summer is warm enough, as represented in the means of temperature, at every point cited for the United States, and if the period of growth could be brought between April and October, inclusive, there need be no restriction on the side of temperature. The whole practical question turns on the possibility of breaking in upon the full tropical habit of the plant, and in its consequent compression into a summer period, simply, though of course having sufficient heat, after the manner of Indian corn. If the severity of the recent winters is to be a frequent fact in that part of the United States, the profitable cultivation of the cane in any part of Louisiana also turns upon the same inquiry, and if the ultra-tropical characteristics of the cane plant may not be modified, serious losses are certain to ensue in its cultivation in our best districts.

The degree of humidity and amount of rain may be supposed to be important, and perhaps controlling conditions of climate affecting this cultivation; though how far they are so has been but little examined by the aid of statistics. There is much reason to suppose that they are secondary in their effects, or that the high fertility usually attendant upon such climates, and resulting from them in the accumulation of vegetable matter and alluvial soils, is the only necessary element. The distinction is not important in the range of the cane for the States near the Gulf of Mexico, since the quantity of rain is everywhere large, except in lower Texas, but in the smaller fertile tracts of the Pacific coast it may be worth examination for practical purposes. On the side of excessive humidity, it is at least known that there is none but a merely mechanical obstacle to the fullest success of all staples analogous to the cane, and that it is not limited by any known measure of quantity of rain falling, or of sensible humidity in the atmosphere. The saturated atmosphere of the low coast of Mexico, the *tierras calientes* or hot lands, and the rainless plateaus of certain tropical and transition districts are, apparently, alike suited to other conditions of growth than the soil.

In the following table several points representing the cane and cotton regions of the United States are cited, with their averages of rain for each month and season; and the table may serve for reference in the consideration of the requirement of the cotton plant. This is known to be injured by excessive humidity, at the same time that its amplest growth requires abundance, if not profusion of rain, as a guaranty of productive soil if nothing more. The references in regard to the sources of the statistics will be found in the general tables.

Mean Monthly and Annual Fall of Rain in the Sugar and Cotton Districts of the United States (inches and tenths vertical depth).

PLACES.	No. of years.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Sum.	Aut.	Wint.	Year.
Whitemarsh Is'd	4½	2.3	1.7	3.3	2.0	4.6	3.5	4.7	5.1	4.8	1.6	2.3	2.9	9.9	13.4	8.7	6.9	39.1
Savannah . . .	14	2.6	2.6	4.2	1.9	5.7	4.7	9 4	9.3	4.9	3.1	1.7	3.2	11.8	23.5	9.7	8.4	53.4
St. Augustine .	3	2.1	1 6	2.8	1.1	2.5	3.0	3.6	5.7	2.5	3.0	0.5	2.1	6.4	12.3	6.0	5.8	30.5
Cedar Keys . .	2½	2.6	1.3	2.7	1.2	1.1	5.8	10.6	5.5	11.7	3.6	2.9	2.4	5.0	21.9	18.2	6.3	51.4
Fort Brooke . .	13	1.8	2.8	3.5	1.7	3.2	6.7	11.2	10.4	7.2	2.5	2.0	2.3	8.4	28.4	11.7	6.9	55.5
Mobile	10	5.7	5.4	3.9	4.4	4.3	6.2	6.3	6.8	2.8	3.1	6.3	5.8	12.6	19.4	12.2	16.9	61.0
New Orleans . .	13	6.5	4.4	2.7	4.1	3.4	5.4	6.5	5.5	4.0	2.6	3.5	4.7	10.2	17.4	10.1	15.6	53.4
Fort Brown . .	3	1.9	1.9	1.0	0.6	2.4	2.7	1.8	1.9	4.8	4.9	2.5	4.1	4.0	6.4	12.2	7.9	30.5
San Antonio . .	3	0.8	4.6	2.9	2.8	3.2	6.3	2.6	0.5	1.9	1.8	2.3	2.9	8.9	9.4	6.0	8.3	32.7
Fort Croghan .	3½	1.3	4.0	5.3	4.4	2.8	3.5	2.8	1.3	2.2	2.1	3.9	3.1	12.5	7.7	8.2	8.4	36.7
Fort Towson . .	14	3.4	3.1	4.4	5.6	5.5	6.2	5.4	4.0	3.2	4.6	4.6	2.8	15.5	15.6	12.4	9.3	53.0
Fort Jesup . .	9	4.4	2.7	4.6	4.7	3.8	4.6	3.8	2.8	2.9	5.1	3.1	4.1	13.1	11.1	11.1	11.2	46.5
Natchez . . .	8	6.3	4.3	4.7	4.6	5 5	4.9	5.4	3.3	5.2	3.6	4.5	5.8	14.8	13.6	13.3	16.4	58.2
Jackson . . .	3½	5.5	6.1	2.4	5.3	3.2	4.6	6.2	3.4	0.9	2.4	6.2	6.8	10.9	14.2	9.5	18.4	53.0
Vicksburg . .	3	9.9	4.2	3.9	3.1	3.0	3.7	2.2	4.8	3.8	3.5	3.9	2.2	10.0	9.5	11.2	16.3	48.4
Memphis . . .	3	3.3	6.6	4.2	3.4	3.4	3.1	1.8	2.9	1.5	2.9	3.5	5.1	11.0	7.8	7.9	15.0	41.8
Monroeville . .	4	3.6	7.7	4.8	6.5	7.9	5.2	7.7	8.6	1·5	1.6	5.6	4.9	19.2	21.4	8.7	16.2	65.6
Perry	2¼	1.4	2.9	2.5	3.5	4.3	3.3	5.1	8.2	1.3	1.5	9.2	3.5	10.3	16.5	12.0	7.8	46.7
Charleston . .	10	2.3	2.2	4.5	1.8	4.3	4.3	6.4	7.3	5.7	2.5	1.5	3.1	10.6	18.0	9.7	7.6	45.9

It is not supposed that these results give any definite guide in regard to the limits of the sugar region; they only show that it is generally rainy, and, as it now exists, less subject to the droughts which prevail at intervals over parts of the south than the cotton districts. At the earlier periods of the introduction of the cane it was vigorously pushed towards the interior of South Carolina, and in Georgia and Florida; but with little success. It was thought in some cases that the droughts restricted it, but usually the impossibility of preserving it through the winter most discouraged its cultivation. The border of the present cane district is much more liable to intervals of protracted drought than lower Louisiana and Florida, as may be seen at the stations in Georgia and Alabama at a little distance from the coast,—Perry, Monroeville, Jackson, Miss., and Memphis. In Texas the point may be more decisively tried, since the coast at Corpus Christi and Fort Brown must be sufficiently warm, and if the cane may bear the comparatively dry climate, it should be eminently successful.

The latitudes of Texas corresponding with those of its greatest success in Louisiana are not adapted to it for several reasons, the reduced temperature being the principal. The changes are too sudden, also, and the sweep of the winter cold more extreme; making the risks greater than the averages of temperature would lead one to suppose. In all of it the summer curve of heat is sufficient for the best result if the period of growth could be shortened, and the extension of this most desirable cultivation now rests on the solution of the single question of capacity for acclimation to a period not so great as ten months.

As a general fact indicating climatological characteristics the presence of this extreme tropical form as a successful commercial staple is extremely significant, and it sustains the analogies derived from the great success of its associate, Indian corn, and the great area covered at favorable spots by yuccas and the native cane of the river marshes. The sorgho, a cane of Chinese origin and similar characteristics, also grows freely, and may ultimately prove to have value as a sugar producer. There are many minor

forms of these strong succulent plants, in which the ripening process develops a great quantity of saccharine matter, that belong pre-eminently to the climate of the United States; and bearing this fact in mind we may yet add valuable staples and plants of a like character, with a measure of success the more important from the fact that few or none of them will grow in Europe.

In actual cultivation the cane is being extended in Florida and in lower Texas, in both of which States there are large areas quite as safe from extremes of cold as in Louisiana,—taking the counties bordering the Gulf in Texas, and the central tracts of the Florida peninsula. A very little appears in States quite remote from the Gulf, in both Kentucky and Tennessee sugar is actually made from the cane, and it has long been the practice to provide for the domestic demand on the smaller estates in Georgia and parts of South Carolina by planting small patches of cane. In New Mexico it is said that the saccharine development of the stem or stalk of Indian corn is such that sugar is made from it in the same manner for domestic supply. The very high measure of temperature attained in summer there, with a cold winter and dry atmosphere, favor this saccharine form of the ripening process in the highest degree.

In Texas the present year, 1856, has exhibited its greatest feature of disadvantage in a severe, and protracted drought. The want of moisture in the soil is an irremediable injury, but it does not appear that a dry atmosphere simply, as that from the Rio Grande to Brazoria and Galveston usually must be in summer, is decidedly injurious.

COTTON IN THE CLIMATE OF THE UNITED STATES.

In the case of cotton we have a vegetable form essentially different from those before considered, one characterized by an absence of nutritive production either in the stem or grain, and therefore not analogous to the cane and corn in any essential feature of the plant itself. The cotton plant is very variable when brought from the tropics to transition and temperate latitudes; a woody form, and a tree of some size in the tropics, to which its native growth appears to be confined, it becomes perennial in the root only first, or perhaps biennial in that form, and at last a very tender annual, and wholly herbaceous. What is more remarkable is its flexibility in being carried from one climate to another, the same species soon putting on the woody form in going south, and with a little greater difficulty perhaps, changing back again from the woody to the herbaceous form.

In the United States the first impression conveyed in comparing the cotton districts generally, is that it is here much beyond its natural range northward. At this extreme limit it first rises to a great commercial staple also, or attains its highest point as such in repaying large investments in its cultivation. In this respect of flexibility of form, and great productiveness near its climatological limit, it resembles Indian corn, and develops a similar relation to climate. Its diminished size and shortened period of growth favor great productiveness in the same manner, and the annual of a few months of growth is far more valuable than the tree of the tropics. In the upland districts of

the southern States it is now proving capable of still more compression in time, and a smaller form, while it is still highly profitable, more so on rich soils than in the semi-tropical districts of India where the herbaceous form is with difficulty retained. The best American cotton districts are near the border of the sugar region and not within it, where the humidity at least is decidedly less, and the productive upland belt lies yet outside this. In this last the adaptation of climate is quite up to the highest requirement, and a rich soil alone is necessary to success.

The area of most profuse summer rains gives frequent seasons in which the stem is weakened, and the blooms and bolls are injured by the excess of rain, and when this is the case a great reduction in the quantity produced occurs. In some cases great injury is done mechanically in the heavy storms of the sugar region, and by so much the cultivation is repelled from the area best adapted to sugar. Still the whole range of cotton is liable to excessive rains and periods of saturated atmosphere, and it shows a decided flexibility in resisting and recovering from such injuries. A month of favorable weather following one of profuse and injurious rains will bring out new blooms and add largely to what at the time appears to be a ruinously low production.

The measure of heat alone does not appear to restrict the growth of cotton on the side of high temperatures. In parts of Texas the mean of 85° for the summer prevails without injury to the plant, and only a few points in the transition climates near the head of the Gulf of California here, and in the vicinity of the desert belt of Africa and Asia, give higher temperatures. In all these cotton is more or less grown, though the soil is unfavorable to extensive field culture. On the low temperature side the summer excess in the United States would carry it to the 40th parallel but for the shortened season; in the best districts it continues to grow and bloom through the autumn until frosts cut it off, and it even may do so through the earlier winter months when they are free from ice, as they sometimes are at the immediate borders of the Gulf. It is persistent as long as the season will permit wherever it is planted, and the time required to produce a remunerative growth of fibre, which must always extend through the entire month of September without frost, is the only check on its cultivation wherever the summer is as warm as at Philadelphia, Cincinnati, and St. Louis. At many localities northward of these points the summer heat would also develop the plant while the summer lasts.

In actual cultivation the autumnal frosts are the most important point, and those of the spring next. Under the great range of temperature extremes in both seasons there is a wide belt of country usually favorable, yet subject to great risks, and these risks repel it as a

staple cultivation on large estates. All of Virginia, in the southern half of which it has long been grown for domestic use; most of North Carolina; the tracts lying at 900 to 1000 feet above the sea in all the belt of States southward into which the Alleghanies extend; eastern Tennessee, and all of Kentucky, Indiana, Illinois, and Missouri, are now excluded from staple cultivation for this reason. In the last four of these States, the southern and lower portions of them, cotton may be abundantly grown in favorable seasons, and more or less is still grown as an item of domestic economy but not as a commercial staple. In the upper part of Arkansas it is the same, and in other parts of the last named State, the Indian Territory, and Texas, there are large areas of the best climatological capacity which are yet unsettled, and too new to exhibit staple cultivation. In the immediate vicinity of the Mississippi it is a profitable field crop to the 36th parallel, embracing all of lower or western Tennessee.

The census of 1850 gives the following items of cotton production for these bordering States:

Virginia, . . .	3,947	Bales of 400 lbs.	Illinois, . .	500	Bales (Census of 1840.)
North Carolina, .	73,845	"	Arkansas, .	65,344	" (Including Indian Ter.)
Tennessee, . . .	194,532	"	Texas, . .	58,072	"
Kentucky, . . .	758	"	Texas in 1855,	118,140	" (Galveston Com. Statement.)
Indiana, . . .	14	"			

Schouw gives the following statements in regard to the range of cotton in Europe, though there are no accessible statements of the quantity produced.

"The most northern cultivation of cotton in Italy is near Naples, 41° north latitude, and particularly about Castellamare. Further south, it is found in Calabria and Sicily. When the trade of the Continent was closed under Napoleon, the Italian cotton culture was more considerable than at present. In Spain, cotton is cultivated on the south coast and on the east coast of Valencia, to 40° and 41° of latitude. It is even found on the plateaus. The cotton culture of Greece and the Greek islands is considerable, and it reaches to Constantinople, or about the same latitudes as in Western Europe. It occurs exceptionally in the Crimea, at 45°; but only on the south side of the high mountains, which afford shelter, and cause a locally warm climate. The Asiatic coasts of the Mediterranean, Asia Minor, Syria, as also the Asiatic islands, produce cotton. In Egypt, especially of late years, Mahomet Ali has made great efforts to extend the cultivation of cotton, and it is grown all along the North African coast. Although Asia is colder than Europe in the same latitudes, the cultivation of cotton extends as far towards the north there as elsewhere, as it is met with in Western China and Bokhara, up to 40° and 41° north latitude—probably on account of the comparatively dry and warm summer; and in Eastern China and Japan it reaches the same limits."

Cotton is by no means limited in its range in cultivation, for the local domestic use of semi-barbarous nations particularly. The vast interior of Asia, as well as Persia, Egypt, and all the transition districts of the old world, have possessed it from the earliest history. Humboldt cites it in the interior of Asia as proof first of a softened climate, and consequently of a great depression of the basin to permit a climate mild enough for cotton nearly at the latitude of Pekin. He quotes a Chinese work descriptive of the country of Yarkand and Kashgar, in which cotton (*gossypium religiosum*) is said to be abundant (*ante*, p. 175). This plain is at 43° to 44° north latitude, and at

1200 feet above the sea as estimated and measured by Humboldt and others; and though the production of cotton proves its climate mild, yet it may be taken conversely to prove the capacity or adaptation of cotton to northern latitudes where the summer is warm. The plains near the Mississippi at the 42d and 43d parallels cannot be much less warm for the three summer months than the basin of Kashgar.

In the still differing climate of the Gila and Colorado rivers of California, cotton was found cultivated by the native tribes, as it doubtless had been for a period reaching into the most remote times. Emory obtained seed of the Pimos Indians in 1846, but it does not appear to have proved a species sufficiently valuable to repay introduction in the planting States. In these localities there is very little rain, and the heats are intense; the air is also extremely arid, and if the absence of atmospheric humidity could operate injuriously such an injury would appear.* As it is, it there appears to be a less luxuriant and perhaps smaller plant only, a difference mainly due to the thin and unproductive soil, or one for which this cause is quite adequate, at least. In the interior valleys of Northern Mexico, Chihuahua and Sonora, it is also cultivated, where the elevation is much greater than on the Gila, and there is no climatological limit over the great area of southwestern Texas, at least for this species of smaller growth belonging to the north of Mexico. This part of Texas is intensely arid, but not more so than the Gila country; the only probable ground of restriction is the great range of extremes there at the cooler months.

But the possible range of some variety or species is of less importance than the staple cultivation which is eminently characteristic of cotton growing in the United States, and no part of the world elsewhere has expanded its production in the same way to answer the immense demands of commerce and civilization. This demand is yet far from its maximum, and it is of great importance to examine and extend the area over which this ample growth can be supplied. The climate is undoubtedly at the basis of this capacity, and whatever the soil there must be a supply of heat and moisture adequate to a luxuriant and ample growth. If it cannot be made cumulative in a certain sense, as field cultivation of Indian corn and its associates may be, it does not repay investment as a commercial staple, and it is as such alone that its production can be expanded to meet the excessive demand of the time.

Texas offers a field in which the question of capacity for expansion over a dry district may be tried, and it is worth decisive efforts to ascertain whether the annual plant now cultivated at the south is the only form which will permit expansion and field cultivation. It is now perfected as an extra-tropical plant, yet its district is here a half-tropical one, with a profusion of rains and moisture on the whole. In Asia—the Kashgar Basin, Persia, and other districts—the ages of cultivation for such supply as the nations there require, and the like cultivation in the north of Mexico, imply other capacities, and the possibility of introducing varieties of a period of growth still less, and a better adaptation to dry interior areas. With the present perfected machinery for carrying on this cultivation as a commercial business, the fullest inquiry into this point is commended to the agricultural interest at the south, if it may not, indeed, be extended to all the rich lands now occupied in hemp and tobacco in the interior nearly to the 40th parallel.

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* Of the country near the Gila river in California and Sonora Col. Gray remarks: "Large tracts of land on the Gila and in other portions of this district appear to possess the requisite properties of soil, and I have no doubt the finest cotton will soon be extensively raised, and brought to its highest state of perfection by proper cultivation. The cotton of which I procured specimens, though cultivated by the Indians in the most primitive manner, exhibited a texture not unlike the celebrated Sea Island cotton. Its fibre is exceedingly soft and silky, though not of the longest staple." (Report of Surveys for a Rail Road Route.)

The cultivation of cotton in the south of Europe is yet below the measure of demand there for it. For this there are several reasons not belonging to the climate—the irregular soil and diversity of products, and the difficulty of systematizing labor on estates suited to it. In part the difficulty is one of climate also, and its incapacity for luxurious growths and for the peculiarly free development of the plant in the southern States here is not less a cause of restriction. It is sufficient proof that these difficulties together are quite insurmountable, that there has been very little expansion of European production of cotton under the immense pressure of demand caused by the great British manufacturing system, notwithstanding the direction of special efforts toward increasing it, both by parties in England, and in Italy and the other countries having capacity for it.* The French have vigorously pressed its introduction into Algeria with a greater degree of success than has attended the like efforts elsewhere, yet it still has little natural footing there, and is sustained by bounties and special inducements.

Several elaborate works have been written in England advocating the extension of cotton culture in India, and in most cases claiming that this extension may be made successful and to supply in some measure the immense requirement of British manufactures independent of the United States. But the most recent of these afford no reason to change the views heretofore expressed that none of the propositions or plans is likely to affect the great sources of commercial supply. It is of course desirable to extend cotton culture as much as possible everywhere, and the able efforts made by the British in India and elsewhere are not lost.

The capacities of India have been most fully tried within a recent period in persistent and well directed efforts to extend this cultivation. The wants of the British Government, and the interests of their rule in India, have induced every effort to initiate new modes of cultivation, as well as to improve upon those now in existence there, and the American species and processes were transplanted as a whole in the hope of attaining a success of the same character. But the American adaptation was apparently itself a spontaneous result, and not the triumph of a conflict with climatological difficulties ; and it appears to be wholly impossible to transplant its peculiar success. To the most of India the biennial or perennial species are best adapted, and its tropical climate not only injures the annual varieties, but also soon changes them to perennials.

Whether the tropical varieties which are shrubs or perennials may become field staples under any circumstances is doubtful, and they have so far had little importance in commerce. The tree cottons are not prolific in fibre for the space a plant covers, and the fibre is rarely such as may compare with that of temperate latitudes in fineness, and in all valuable qualities. It is evident that whatever the home of the cotton plant primarily, it is most valuable near the northern or cold limit of its actual cultivation, and that the great advantage there is climatological.†

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* Of these efforts in 1856 the *London News* states that Egypt had taken them up anew, and that France was doing all in her power to encourage its growth in Algeria by guarantying good prices. In the same mode English interests were proposing to act in Italy. In the Kingdom of Naples, including Sicily, it is stated by the same authority that 4,200,000 pounds are now grown annually while the consumption is 5,000,000 pounds. Of this quantity 2,000,000 pounds are produced in Sicily, half of which is sent to Naples, and the remainder is produced on the two coasts of the peninsula at about the 41st parallel. For the consumption of the kingdom 800,000 pounds annually are yet brought from New Orleans. A decided increase is necessary therefore to permit any exportation.

† The commercial sources of cotton production are very few, as the following

It is difficult to seize on the features of climate which constitute this advantage and give them a distinctive form. They belong in part to the daily temperature curve, and still more to the temperature curve among the months, or for the year. The temperature extremes which cut it off by frost come next after the averages which give these facts, and the mean quantities and extremes of rain are also important. In a table previously given the quantities for a sufficient number of stations to represent our best districts have been cited. By reference to these it may be seen that coasts of a moderate and uniform humidity, without the great excess which sometimes prevails beyond the reach of the sea breeze, afford the most favorable localities. The celebrated Sea Island cotton of the Atlantic coast is represented by the observations at Whitemarsh Island, on the coast of Georgia, and here the excess of heat, and of rain and local humidity, which occurs at intervals inland and proves so injurious, is prevented by the influence of the sea, and the consequence is the finest staple known. By some its excellence has been attributed to the saline qualities of the sea air, but the more natural solution is in the equable temperature and humidity of this sea atmosphere, and the absence of irregularities of growth when it is forming, and of subsequent injury. The temperatures are lower also, as the following table will show, and the locality has the general advantages of the American climate while it is exempt in a great degree from its injurious extremes.

There are no observations of humidity simply, or of the dew point and hygrometer, to afford a comparison with other districts. The quantity of rain only roughly exhibits this precise condition, but it is known that the atmosphere approaches saturation at very frequent intervals during the summer months on the Gulf coast, and that when rain falls inland it is likely to be excessive and to be attended with complete saturation. It is from these extremes that coast islands escape, and the true Sea Island cotton can doubtless be made to succeed at all exposed points of the entire northern coast of the Gulf, as well as on the Atlantic. It is difficult to separate extremes from averages in this more sensitive phase of the climatic relations, and the tracts where the averages would not differ materially might present important irregularities of this sort. The special sugar region is the worst of these humid localities next to the excessive summer rains of the tropics, and the inland belt between the coast and uplands is next. In this last place great injury is sometimes done, while generally the staple or fibre is good. The uplands are less liable to it, and not more so than the best positions within reach of the sea breeze. The upland fibre is superior apparently for this reason, and though the plant is less luxuriant and less productive in absolute weight, the value of it is greater than on the lower lands.

The following averages may add something to those before cited, and the comparison of preferred positions may be more widely made. The minimum temperatures or low extremes will serve to illustrate that branch of climatological capacity to some extent, though observations of this character should be connected with statements of the actual effect and precise date of the extremes. Frost is destructive to a large number of plants and staples peculiarly American, and the climate is eminently liable to them at the borders of each cold season. They occur at different air temperatures also when different hygrometric conditions prevail, and the observation sometimes fails to represent the refrigeration which actually cuts off the sensitive plants.

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statement of importations into Great Britain for the year ending Jan. 5th, 1854, will show :—

From the United States	1,469,752	Bales of 400 lbs each.	
" Brazil	51,497	"	"
" Egypt	62,652	"	"
" British India	404,766	"	"
" Other ports	4,417	"	"

(*British Commercial Statement.*)

Mean Temperatures of Specially Important Districts in the Cultivation of Cotton.

PLACES.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Sum.	Aut.	Wint.	Year.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Whitemarsh Is'd, Ga.	48.3	53.1	58.5	63.1	71.9	76.3	79.1	79.1	73.9	66.0	56.7	52.1	64.5	78.2	65.5	51.2	64.8
Savannah	52.6	54.7	60.0	68.4	74.8	79.4	81.3	80.6	76.9	67.2	58.3	52.2	67.7	80.4	67.5	53.0	67.2
Cedar Keys . . .	53.9	59.7	67.3	68.7	75.8	78.6	80.5	80.7	78.7	73.1	64.4	59.8	70.6	80.0	72.1	57.8	70.1
Havana	65.3	70.0	72.0	75.4	79.7	83.7	85.2	83.6	80.6	78.4	72.6	70.0	75.7	84.2	77.2	68.4	76.4
New Orleans . . .	54.8	54.4	61.5	67.6	74.0	78.6	80.4	79.6	77.1	69.1	57.5	56.2	67.7	79.5	67.9	55.2	67.6
San Antonio . . .	52.7	57.8	65.5	69.7	76.4	80.5	82.3	83.8	79.9	72.2	62.2	52.1	70.5	82.2	71.4	54.2	69.6
Fort Smith	41.6	44.8	50.2	63.1	69.1	75.7	79.6	78.1	72.1	60.3	49.7	40.0	60.8	77.8	60.7	42.1	60.2
Jefferson Barracks .	33.6	35.2	45.5	58.1	67.1	74.4	78.2	76.7	68.4	56.0	45.8	35.5	56.9	76.4	56.7	34.8	56.2
Lebanon	33.7	38.5	47.3	53.9	66.4	73.2	76.4	74.1	68.0	57.0	46.9	35.2	55.9	74.6	57.3	35.9	55.9
Huntsville	42.0	42.6	51.3	61.3	67.2	74.2	76.4	76.2	70.1	59.5	49.7	41.8	60.0	75.6	59.8	42.1	59.7
Chapel Hill . . .	42.0	44.0	51.2	69.5	67.2	74.6	77.7	75.5	69.7	59.2	51.6	42.8	59.3	75.9	60.2	42.9	59.6
Fort Monroe . . .	40.5	40.9	47.5	56.1	65.9	74.1	78.3	77.1	71.4	61.7	51.2	43.2	56.5	76.5	61.4	41.5	59.0
Camden	44.7	49.9	55.6	60.6	71.0	76.2	79.7	77.8	73.3	62.2	52.3	47.7	62.4	77.9	62.6	47.4	62.6

Lowest Temperatures Monthly at Stations within the Limit of the Cotton Region.

YEARS AND STATIONS.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Chapel Hill, N. C.	°	°	°	°	°	°	°	°	°	°	°	°
1849	..	..	..	..	47	58	55	60	51	35	32	20
1850	18	12	27	30	47	55	65	62	51	32	24	18
1851	6	11	30	38	40	54	65	56	46	33	28	10
1852	1	23	27	34	41	51	66	59	51	40	29	29
1853	16	26	15	37	48	60	62	57	43	32	28	19
St. John's, Berkeley, S. C.												
1846	..	..	29	40	55	58	62	71	58	40	22	24
1847	15	27	28	37	43	64	64	68	53	44	29	21
1848	24	25	27	39	47	58	70	66	51	42	25	33
1849	17	21	37	27	47	63	61	69	53	42	33	31
1850	26	24	31	34	39	53	69	69	53	37	29	28
1851	14	10	20	36	37	52	63	61	43	31	20	10
1852	7	18	26	32	40	52	68	62	58	45	25	26
1853	18	21	25	33	38	57	63	58	49	30	24	34
Whitemarsh Island, Ga.												
1849	..	..	..	..	48	66	64	71	58	48	37	32
1850	31	25	39	44	54	58	71	70	59	37	33	28
1851	23	27	34	45	53	60	70	65	42	38	29	18
1852	10	28	31	44	51	61	72	65	60	50	33	31
1853	26	30	34	50	60	67	74	72	59	40	40	29
Erie, Ala.												
1849	..	..	..	39	60	68	69	74	61	47	37	19
1850	27	17	30	40	46	61	72	73	65	32	24	21
1851	21	27	26	43	45	63	60	68	42	30	27	10
1852	2	28	26	42	57	58	69	64	56	48	29	28
Huntsville, Ala.												
1831	18	13	20	32	42	56	60	56	39	33	24	0
1832	—9	14	13	44	50	53	58	57	50	39	28	24
1833	16	23	11	36	55	56	59	57	52	42	24	27
1834	11	29	27	38	45	58	62	61	48	29	24	24
1835	22	—4	12	37	46	54	51	54	43	33	19	22
1836	—9	—7	21	34	50	58	58	58	46	29	14	9
1837	13	17	27	31	40	50	60	54	46	35	24	22
1838	18	8	31	33	41	50	64	63	40	29	20	—7
1839	22	16	13	37	42	52	60	62	43	42	13	17
Lebanon, Tenn.												
1851	6	12	13	33	33	58	57	62	35	19	19	2
1852	—7	21	15	32	39	47	60	57	46	33	18	20
1853	17	10.7	23	40	49	64	71	59	46	31	27	17

The first part of this list represents the warmest cotton climates of the United States. The best single station, Whitemarsh island, Georgia, (near the mouth of Savannah river,) which is a representative of the Sea-Island climates, is seen to be much cooler than Savannah, or any other in this part of the list. Humidity enters

largely into the account also, and by reference to the amount of rain at the four stations of Savannah, Cedar Keys, Havana, and New Orleans, it is shown that they are so much more humid as to render the temperature measures too low for just comparison with other localities. San Antonio is drier, and its temperatures better compare with the second list.

In the second part of the list, limiting stations on the north are given. Jefferson Barracks, Missouri; Lebanon and Knoxville, Tennessee; and Chapel Hill, North Carolina, with Fort Monroe, at the mouth of the Chesapeake, Virginia, are all beyond the present actual field cultivation, and each is probably too cold for complete success. Fort Smith, Arkansas; Huntsville, Alabama; and Camden, South Carolina, represent the best northern cotton districts near the limit of its extension.

CULTIVATION OF THE VINE IN THE UNITED STATES.

THE vine, or grape, is perhaps more than anything else a growth of very definite climatological position, or it has come to be such in the European efforts to extend it to its utmost limits, and where the average surface of the country is scarcely favorable to it. Its permanence through centuries in these narrow localities and extreme positions, where a very small measure of change would cut it off altogether, is justly held to be one of the strongest proofs of permanence of climate, and that no essential change has occurred in these parts of Europe. There, also, both temperature and humidity, with the quantity of rain, are defined to be permanent by the permanence of the vine; since in the districts of the Rhine and the north of France a very slight change of either would cut off wine-making altogether or alter the peculiarities which now distinguish these vines from others grown farther south. For these reasons great importance has been attached to wine-growing as a climatological indication, and we may use European results to illustrate our own capacities, negatively if not positively, or so far as to say where the vine cannot succeed.

Greater difficulties are presented here in attaining precise definitions than in Europe. The temperature is not so reliable as a guide, either in extremes or in means as it is there, and there is a wide range of doubtful ground on either side of the measures positively favorable. The variations both in single readings and on the means for a month or more, are so considerable as to quite exclude places having the same average temperature for the summer months as that of a superior wine district of Europe from the possibility of producing European grapes at all; the mean of 67° for the summer, which is 2° above that at Paris, Strasburg, and Berlin, giving the best localities on the Rhine, while the same mean here—Boston, Burlington, Vt.; Toronto, &c.—will not ripen European grapes fit for wine in the open air.

Another difficulty of definition here is found in a similarly variable measure of humidity; an excess at times, and high averages, suc-

ceeded by very low extremes, and these abruptly giving place again to great saturation. This is a condition to which the grape is peculiarly sensitive, and under it the effects of temperature do not remain the same, apparently. The structure of the plant and fruit in the best European varieties is peculiarly delicate, and its quality and value rapidly depreciate in an unfavorable atmosphere, inducing the rot and mildew so frequent in American cultivation. In defining this liability our averages of rain fall are the only statistics that can now be employed, and it is even doubtful whether positive observations of humidity would give averages that would disclose the peculiarity. The extremes would do so, or if there were added to these the numerical statement of the frequency of such extremes, but the observations at localities where the hygrometer has been observed have not been prepared for any form of statement like this.

In Europe the advantage of precise adjustment to the capacity of any locality which is afforded by the peculiar climate is improved to the utmost in cultivation, and the vine passes the natural limit in consequence of this refinement of care; or rather, mere localities are made available where the general condition repels it. Thus the narrow sheltered valleys of Northern France and of the Rhine furnish localities of very successful growth, while the greater portion of the interior of both France and Germany, stretching southward for five degrees of latitude from the vineyards of Nassau and the Maine, is too cold for the vine. The interior rises in plateaus of considerable elevation, the changes of temperature become greater, and the climate as a whole too variable. An interesting proof of this close adaptation of cultivation to climatological capacity is seen in the historical citations of the growth of vines in England, given in another place.

As we derive our definitions mainly from this actual European range, it may be necessary to give the general facts of vine distribution there, with some notice of the climatological limits so frequently assigned in European treatises. Kaemtz assigns latitude 47° 30′ on the Atlantic coast of France, 49° in the interior, and 50° 20′ on the Rhine at Coblentz, as the northern limits so far. "In Germany it does not pass 51°, to which line it is sensibly parallel in Eastern Europe." These are extreme limits, and they could not be taken as the boundary of the best northern districts. A degree and a half of latitude, and the positions of Bordeaux, Dijon, and Manheim, would represent these; and east of the Rhine there is little good wine north of the valley of the Danube. Schouw traces the limiting line somewhat south of that indicated by Kaemtz, and places it nearly on the limit of Indian corn, from which it is, in some parts, removed even half a degree south. From the west it comes in at Nantes, going due east to nearly the meridian of Paris, then north to $49\frac{3}{4}$° of latitude, and after a small southward curvature north again to latitude 51° on the Rhine; then with similar curvatures to Berlin, from which last point it is vaguely traced nearly due east to the Black Sea. Johnston gives lines of "northern limit" of maize and the vine, putting that of the first a degree and a half to two degrees further south, and placing both in lower latitudes than Kaemtz; indicating, however, "favorable locali-

ties" and valleys where each is cultivated north of these general limits. The definition sought here is the precise measure of temperature belonging to the locality, and for this a record at these favorable points is necessary.

To exhibit this degree of precision the comparison of favorable and unfavorable seasons made by Boussingault* may be cited as one of the clearest statements yet made. The locality is the vineyard of Schmalzberg, in Flanders.

Years.	Mean Temp. of whole time of growth.	Mean Temp. of the summer.	Gallons of wine per acre.	Percentage of Alcohol.
	°	°		
1833	58.4	63.1	311	5.0
1834	63.1	68.5	413	11.2
1835	60.4	67.0	625	8.1
1836	60.4	71.0	544	7.1
1837	59.3	66.0	184	7.7

"In 1833 and 1837 the wine was scarcely drinkable; in 1834 and 1835 unusually good." The relation of temperature is seen to be very direct, and that a summer below 67° will not produce any valuable quantity or quality.

Blondeau† makes a comparison for the department of Aveyron, in South France, where the elevation is such as to bring the locality, Rodez, almost to the precise limit of possible growth of the vine. "In the environs of Rodez but a single plantation of vines appears, and as it is very rare that the fruits produced attain to sufficient maturity to make good wine, this single vineyard remains as a definite mark of the limit beyond which vineyards may not go." The mean annual temperature of this locality is 50°.5, but as this is nearly equal to that of Paris, (51°) and above that of vine districts of the Rhine, (48.2° to 49°.1) the limitation is to be sought in the means for the seasons, or in the ranges of temperature. Blondeau indicates that it is to be found in the mean temperature of the spring, which he compared with that of Paris for three years as follows:

	Paris.	Rodez.
	°	°
1846	59.0	57.2
1847	55.7	54.7
1848	59.4	56.5

The summer mean is as high at Rodez as at Paris, both falling below 65°, which is the lowest permitting the vine to succeed. The cold extremes and bleak winds of spring on the plateau of central France are referred to as the cause of the failure of the vine at exposed localities where the summer is warm enough in the averages of temperature.

In the following table from Humboldt the summer averages appear clearly in their relation to successful growth of the vine, the first station, Cherbourg, being wholly unproductive, Berlin partially so, and Manheim and Bordeaux fully so. Two stations are added for the United States; at Cincinnati it is successful, and at Highland (Illinois) the European grape is wholly cut off by the severe winter.

		Years.	Spring.	Summer.	Autumn.	Winter.	Year.
			°	°	°	°	°
Cherbourg, France, lat.	49° 39′	3	50.8	61.7	54.3	41.5	52.1
Berlin . . . . . "	52° 31′	23	46.6	63.6	47.5	31.0	47.5
Manheim, Rhine . "	49° 29′	12	50.8	67.1	49.5	34.6	50.6
Bordeaux . . . . "	44° 50′	10	56.0	71.0	58.0	43.0	57.0
Cincinnati . . . "	39° 06′	18	53.8	73.7	53.6	33.8	53.7
Highland, Ills. . . "	38° 40′	12	55.7	76.5	55.5	33.4	55.3

From these citations it may be seen that the mean annual temperature is not a guide alone, and that no single season may so be taken. In Europe the relations of the summer and winter are such that if the first is found to gain a sufficient measure

* Rural Economy, p. 255.

† Annuaire Meteorologique de France for 1850.

of heat the winter may be disregarded, at least for the west of Europe. But here the case is different, as is strikingly shown by the observations of Dr. Ryhiner, at Highland, who says that "of a large number of vines from the Rhine and other sections of Germany and France planted here four or five years ago not one survives; they generally perished during the winter, the plants being frost killed several inches into the ground. The mean temperatures show our spring, summer, and autumn to be nearly as warm as Bordeaux, while our mean winter temperature is as low as that of Frankfort-on-the-Maine." The mean of winter at Highland, 33°.4, is somewhat above that indicated by Humboldt as the extreme limit of the vine, and it is doubtless owing to the great severity of the non-periodic extremes that it proves so destructive to the European grape.

The comparison of mean temperatures for the year shows at once that this single item is no guide in the American climate; Nantucket, New Bedford, and New York on the Atlantic coast, and Monterey and San Francisco on the Pacific, are equal or nearly equal in mean annual temperature to Paris, yet the mutual relations of the two points to vine cultivation are widely different. These equable stations are far more likely to be favorable to the European grape than interior points, and at Highland, previously cited, there is an excess of 4 or 5 degrees in the annual mean over the wine districts of France from which the vine has been brought in vain. The mean of 49° has been assigned by Humboldt as the minimum requirement, yet we find European forms impossible of growth here at an annual mean of 55°, and again to some extent successful at 47° and 48° near Lake Erie; in a district not very remote from the high temperature districts where cold extremes cut it off entirely. The western shores and islands of Lake Erie at $41\frac{1}{2}$° of latitude are scarcely inferior to Cincinnati in capacity for grape culture, the average annual mean temperature being 48°—at Oberlin, Ohio, 48°.3.

As a rule the culture of the best European varieties is very much restricted in the United States, and next to the variable temperatures the variable degree of humidity and its frequent excesses are the causes of the injury. The deficiency is not so much in the perfection of saccharine matter as in the preservation of the exterior and substance of the fruit under the disorganizing influence of the heat and moisture; mildew and rot become very destructive at times. These humid conditions and extremes are of very irregular occurrence, having the non-periodic character belonging to all the features of our climates, and every district east of the plains is liable to them at all times in summer, though it may happen that none occur through an entire year. They alternate with dry periods of the most favorable character, and one ripening season may be wholly dry, while another is so warm and wet as to destroy much of the growth of even the hardy American varieties.

As has been said, this fact of liability to injury is one which it is difficult to assign precise values, and it would scarcely appear in the averages of humidity derived from any form of hygrometric observation, as the dry extremes would balance those of excessive moisture. The quantity of rain falling for the summer months is the best general indication that such extremes occur, and in the American climate, at least, they are found wherever the quantity of rain is great, and the temperature high.

In Europe the difficulty from this cause disappears, and they have only the temperature to consider. If the proportion of saturation is not always less, the positive quantity of moisture and of heat is so much less that the injury from them is very little. Humboldt refers to the excellence of the grapes grown at Astrachan, on the Caspian Sea, and pronounces them equal to the best of Italy. It would be interesting to compare the varieties grown there with those of Western Europe, and as the range of temperature at Astrachan is even more extreme than in any part of the United States, varieties found to succeed there might be transplanted here successfully. The climate of Astrachan is conspicuously dry, probably not less so than that of New Mexico.

It is very difficult to give significant statistics for the vine districts of the United States, since so large an area is generally so near success, and localities of particularly favorable exposure may, with the exercise of great care, produce fine grapes in the open air almost as far north as corn will grow. Near New York city, in central New York, western Canada, Ohio, and Michigan, and again near the Mississippi to a high latitude, these favorable localities exist, and the best seasons may show such a growth of fine varieties as to induce the opinion that they may be cultivated to any extent. The following tables may give some new items for the comparison, though they are insufficient for positive definitions, if the subject may be supposed to permit them. The authorities will be found in the general tables, with the exceptions noted below.

Climate of the Vine Growing Districts of the United States.

PLACES.	Lat.	Alt.	TEMPERATURE.					AMOUNT OF RAIN—INCHES.				
			Sp'g.	Sum.	Aut.	Wint.	Year.	Sp'g.	Sum.	Aut.	Wint.	Year.
Baltimore, Md. 8 yrs.	39° 17′	193 ft.	52.3	74.3	55.6	34.3	54.1	11.5	13.7	10.2	9.0	44.4
Scuppernong, N. C.	35 50	30	58.6	74.7	60.0	43.3	59.1	10.3	15.4	10.9	10.6	47.3
Chapel Hill, N. C.	35 54	570	59.3	76.3	60.2	42.9	59.7	..	..	..	..	..
Camden, S. C.	34 15	250	62.4	77.9	62 6	47.4	62.6	13.6	20.8	9.8	10.1	54.4
Sparta, Ga. 1852–3	33 17	550	63.9	79.2	68.2	46.5	63.2	11.1	10.5	14.6	15.5	51.7
Huntsville, Ala.	34 45	550(?)	59.9	75.6	59.8	42.1	59.7	14.9	14.6	10.0	14.4	53.9
San Antonio, Texas	29 25	600	70.5	82.2	71.4	54.2	69.6	8.9	9.4	6.0	8.5	32.8
Nashville, Tenn.	39 09	533	59.4	77.5	58.2	39.2	58.6	14.1	14.0	12.3	12.4	52.8
Cincinnati, Ohio	39 06	550	54.3	73.0	55.0	32.9	53.8	11.9	14.2	10.0	11.3	47.5
Cleveland, Ohio	41 42	625	46.4	67.0	51.4	30.8	48.9	6.5	8 7	7.7	9.4	32.3
Oberlin, Ohio	41 23	799	45.6	69.3	49.6	28.8	48.3	9.3	11.4	10.0	5.2	35.9
Ann Arbor, Mich. 3 yrs.	42 10	750	45.5	66.3	48.4	25.3	46.4	7.3	11.2	7.0	3.1	28.6
Battle Creek, Mich.	42 20	800	44.4	70.2	49.9	26.8	47.8	7.5	11.2	7.1	6.8	32.7
New Harmony, Ind.	38 11	400	58.7	76.9	54.9	37.6	57.0	10.5	12.8	7.2	12.3	42.8
Highland, Ill.	38 40	600(?)	56.9	77.9	56.8	34.1	56.4	12.2	13.3	9.2	7.1	41.7
St. Louis, Mo.	38 37	450	56.9	76.2	54.4	33.9	55.5	12.7	14.0	8.7	7.0	42.5
Fort Madison, Iowa 4 yrs.	40 38	600	50.5	73.2	53.1	26.3	50.8	15.3	15.9	14.5	4.7	50.5
Fort Arbuckle	34 27	1,000	61.7	79.9	62.2	40.8	61.1	8.1	8.9	8.9	4.5	30.6
Albuquerque, N. M.	35 13	4,576	52.4	73.1	55.5	34.4	53.8	0.6	5.6	1.2	1.0	8.4
El Paso, N.M., Ft. Fillmore	32 03	3,940	60.4	80.4	61.6	44.9	61.8	0.6	6.6	4.9	0.3	12.4
Rancho del Chino, Cal.	34 00	500(?)	60.8	72.6	64.9	54.8	63.3	2.5	0.1	1.6	5.5	9.7

Scuppernong, Rev. J. A. Shepherd, 2 years' temperature. Rain at Fort Monroe, near Norfolk, Virginia, and for 16 years. This locality would represent the district in which Scuppernong is situated. Highland, the amount of rain is from the record of Mr. Hall at Athens, Illinois, about 60 miles north of this locality, but in the same general surface and exposure.

Albuquerque, 3 years—1850 to 1852. Fort Fillmore, near El Paso, 1 year—1852.

Rancho del Chino, California (the southern valleys of California, near Los Angeles, and in a superior vine district), one and a half year's observations at the military post. The rain is given from measurements at San Diego, a lower position, on the coast. The summer rain is more abundant in this very superior vine district, which embraces the spurs and terminus of the coast range of mountains in the counties of Los Angeles and Santa Barbara. By the State census of 1852, Los Angeles county is reported as having 350,000 grape-vines, and as producing 57,355 gallons of wine. Santa Barbara, Santa Clara, and Solano counties, have a large produce also.

Climate of the Principal European Vine Districts.

PLACES.	Lat.	Alt.	TEMPERATURE.					AMOUNT OF RAIN—INCHES.				
			Sp'g.	Sum.	Aut.	Wint.	Year.	Sp'g.	Sum.	Aut.	Wint.	Year.
Lisbon, Portugal	38° 42′	Sea level	59.6	70.9	62.5	52.5	61.4	..	..	..	..	..
Funchal, Madeira	32 37	1,200	65.6	71.3	69.0	61.9	66.9	5.1	2.3	7.0	16.5	30.9
Turin, Piedmont	45 11	857	53.7	71.5	53.8	33.5	53.1	8.2	9.0	11.5	7.8	36.5
Vienne, Lyons, Val. Rhone	45 32	300(?)	56.2	71.8	54.6	38.7	55.3	10 2	9.5	10.4	4.3	34.4
Bordeaux, W. France	44 50	Sea level	56.1	71.1	57.9	43.1	57.0	7.3	7.4	10.3	9.0	34.0
St. Michael's, Azores	37 50	Sea level	60.6	72.5	65.2	57.3	63.9	6.6	3.6	9.5	11.7	31.4
Vevay, Switzerland	46 28	1,250	50.5	65.7	51.0	35.9	50.8	7.9	10.8	11.1	3.9	33.8
Manheim, Rhine	49 29	258	50.1	67.4	49.9	33.6	50.3	6.3	8.0	7.4	5.3	27.0
Dijon, E. France	47 19	746	53.3	69.6	53.3	35.4	52.9	7.1	7.5	9.3	7.3	31.2
Chalons, N. E. France	48 57	492	51.0	66.8	53.8	37.1	52.2	5.4	6.2	6.1	5.6	23.3
Bucharest, Val. of Danube	44 27	(?)	44.1	65.3	50 1	27.8	46.8	..	..	..	..	..
Astrachan, Caspian Sea	46 21	Sea level	52.6	75.9	52.4	19.2	50.0	..	..	..	..	..

Lisbon.—The temperatures represent the vine growing districts of Portugal and Spain very nearly, though the summer temperatures are lower at Lisbon. No observations of amonnt of rain are accessible, for any of these districts. The summer is, however, known to be dry.

Turin.—Temperature observations for many years. Distribution of rain from Schouw's table for the "Transpadane Belt" of the climate of Italy. The elevated districts of Northern Italy, yet lower than the Alpine, are very well represented by the table.

Vienne.—The amount of rain is the mean fall in the basin of the Rhone for five years through the period of vegetation, April to September; for the remainder of the year the quantities are for 1848 only. This is a favorite wine district.

St. Michael's.—Ten years' observation, by T. Hunt. Brit. Assoc. Reps.

Funchal, Madeira.—The vine district is at an elevation of 1,200 to 1,500 feet, and its temperatures less than those here given. The amount of rain is quite similar to that at the Azores.

Vevay.—The amount of rain is given as measured at Geneva, which is unfavorable to the vine. Vevay, for which no observations of this sort exist, is only known to have less in summer.

Manheim.—Annual mean of rain for Strasburg, and the divisions among the seasons according to Kaemtz's table for the east of France.

Dijon.—Twenty years' observation.

Chalons.—Somewhat more elevated and exposed than the favorite vine districts of the Marne, for no precise locality of which are there any reliable series.

Bucharest.—Two years' observations from Dove.

Astrachan.—A series from Dove, without date.

The most conspicuous feature of this comparison is the excess of temperature and amount of rain for the summer in America, as compared with Europe. Both these measures are here so far in excess, compared with districts in which a similar extent of vine culture exists in Europe, that the parallel seems to fail of significance or of application in this connection. We are, in truth, thrown upon a new trial, and upon the development of new or native varieties which will bear the peculiarities of climate, in regard to which we differ from Europe too widely to transfer their most successful varieties.

In the districts where the temperature and amount of rain are less excessive in summer, the opposite extremes of winter and spring temperatures are quite certain to become injurious. A district bordering the southern and western portions of Lake Erie is more favorable in this respect than any other on the Atlantic side of the Rocky mountains; and it will ultimately prove capable of a very liberal extension of vine culture. None of the stations given in the table represent it precisely, though Oberlin, Ohio, and Ann Arbor, Michigan, differ only in being somewhat more exposed and extreme in temperature at the colder seasons. The amount of humidity is much lower here in summer than elsewhere; and it corresponds more nearly than any other district with the vine-growing districts of the Rhine both in temperature and amount of rain.

The southern portions of the Alleghany mountains, bordering the South Atlantic States and those of the Gulf, possess general characteristics greatly favorable. They have less humidity than the plains below them, reversing the European law of humidity and aqueous precipitation in this respect; and their exposures southward and sheltered valleys must favor this cultivation to a very great degree.

The present wine districts of Cincinnati, and other localities on the Ohio, and those on the Missouri, at Herman, are very successful in every point except the liability to injury from excess of humidity and of rains. The general climate will always present difficulties in this respect which the utmost care in cultivation and choice of position can modify only in degree.

In the lower portion of the valley of the Rio Grande, in New Mexico, the nearest approach to equable temperatures and the requisite low humidity is attained. In the vicinity of El Paso, vineyards are numerous and successful; the rarified atmosphere and slight precipitation of rain being more signally favorable than in any portion of the continent eastward. The cultivable districts in this latitude towards the Pacific must present many localities of proper adaptation in their peculiar conditions, though the extent of these is not great, and the southern valleys of California, sufficiently

distant from the seacoast and from the loftier sierras, would be unusually favorable in regard to these primary conditions.

Upon this point recent information from the southern portion of California is particularly encouraging, and the probable results here indicated appear to be fully sustained. As these features of climate, which are known to be so decisive of the measure of success there, attain singular completeness, as it may be said—that is, the measure of humidity and of temperature becoming of the most perfect mutual proportion—the result is the most extraordinary perfection of vegetable development. This is true of other products—of wheat and the Cereals generally, of some varieties of roots, of particular species of trees, and of the vine and fruits. These advantages occur in distinct localities, however, as if a variable division of the climate had been so arranged as to present conditions in the highest degree favorable to each product in turn.

The range of wild varieties of the grape of a certain class, is very great on this continent. Nearly the entire area of the United States in which Indian corn may be grown, produces, spontaneously, vigorous native species of the grape; and though the edible and valuable varieties are farther south in this wild condition, there must be some significance in this extreme range of the ruder varieties. It is believed that their limit would be the utmost limit of this cultivation under the high preparation and great care exercised in Europe, and that the more perfect fruits when thoroughly acclimated, or developed from wild varieties, may, by skilful cultivation, be extended over the whole area in which the native vine bears an edible fruit. In the northwestern interior this extreme range of native species is most remarkable. Sir George Simpson remarks that "even the vine was abundant" on the Kaministiquoia, a tributary of Lake Superior from the north, and at 49° to 50° north latitude; and others mention its presence there, and again on the Saskatchawan.* Richardson says that "the frost grape, *vitis cordifolia*, grows, on the evidence of collections made in my former journeys, as far north as the south end of Lake Winnipeg on the 50th parallel."

Wild grapes are sufficiently abundant in western Canada, and in Minnesota to the latitude of St. Paul's, to permit the manufacture of wine from them to the same extent formerly practised in eastern Pennsylvania. The limit of this profusion of native wild growth rises five or six degrees of latitude in passing from the Atlantic coast to the Mississippi, and over the immense interior areas westward favorable localities are scattered in sheltered valleys even to the 49th parallel.

The following table of minimum temperatures in the vicinity of the best vine districts of Ohio and Missouri, though at a locality of greater exposure than either, will show how near to these the more delicate varieties are cut off. At the west end of Lake Erie, though much north of these positions, the extremes are less severe and the American varieties flourish well.

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* Journal of a Boat Voyage in Search of Sir John Franklin, vol. 2, p. 287.

Lowest temperatures observed at Hillsborough, Ohio—Latitude 39° 15′.—
Rev. J. McD. Matthews.

Years.	Jan.	Feb.	Mch.	Apl.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.
1836	—14	—11	—8	22	35	50	52	54	34	24	10	—1
1837	4	—3	15	23	32	44	56	44	36	22	22	2
1838	4	—22	6	24	30	46	52	54	34	26	9	—5
1839	6	6	—10	28	30	46	51	48	30	28	2	2
1840	—2	4	16	24	36	44	50	54	..	..	15	4
1841	—8	1	13	28	34	52	55	52	40	26	20	10
1842	9	—4	23	30	38	42	52	46	40	28	2	1
1843	4	—5	—1	24	40	40	56	56	42	22	21	12
1844	—1	10	14	27	37	48	62	..	38	26	12	11
1845	18	8	13	18	36	51	53	55	..	26	9	—12
1846	7	1	17	31	43	48	52	62	47	31	16	18
1847	—4	5	11	24	38	47	52	48	40	27	16	0
1848	—4	13	2	32	42	47	54	56	36	32	22	19
1849	5	—2	25	22	42	56	54	56	42	36	22	—2
1850	4	—2	14	24	36	44	60	54	40	30	24	11
1851	—2	14	20	27	27	48	50	50	39	24	22	—10
1852	—10	14	8	30	35	42	51	51	44	36	25	18
1853	6	—1	15	35	42	57	57	50	44	31	23	7

Lowest temperatures observed at Highland, Illinois—Latitude 38° 40′.—
Dr. Ryhiner.

Years.	Jan.	Feb.	Mch.	Apl.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.
1841	5	—2	19	33	34	48	54	51	43	17	14	15
1842	12	—2	23	37	37	38	48	36	35	28	3	—3
1843	—2	—4	2	22	36	40	50	50	49	23	18	9
1844	5	14	21	33	39	51	62	48	34	24	15	7
1845	18	12	16	20	35	50	54	57	38	21	3	—7
1846	16	—1	17	30	50	50	49	56	49	27	16	18
1847	—5	0	13	29	43	52	56	57	43	27	19	4
1848	—5	8	2	33	47	53	60	62	41	37	15	5
1849	6	—3	27	33	41	61	60	53	48	40	29	7
1850	—8	—2	19	22	42	54	66	59	48	30	25	2
1851	—2	15	24	36	36	63	61	62	38	27	25	—4
1852	—15	15	19	32	48	54	59	58	48	40	20	17

Both these localities destroy the European grape by extremes of cold. Hillsborough is near the best grape districts of Southern Ohio, though its elevation is such as to give much greater single extremes of cold than Cincinnati. The difference in these cases is near five degrees of temperature for each marked extreme.

The natural vine climates of the interior of northern Mexico and of the Pacific coast in California have been very briefly referred to in the preceding comparison, and it should be said that the characteristics and limitations so far mentioned as belonging to the United States do not exist there. The whole tone of the climate is changed, and the analogies of the west of Europe reappear, giving an adaptation to vine growing equal in the most favorable localities to that of the best parts of Spain. The same equable climate, and high but not excessive temperature prevails here, with great uniformity of conditions and very little rain or atmospheric humidity. The south of California has the largest and best of these vine districts, and it will soon attain a high commercial importance in this respect. At intervals in Western New Mexico and Sonora very good localities occur, and at El Paso a fine one exists, requiring protection to the plants in winter, however. At Parras, some distance southward in Mexico, a superior vine district exists where no protection is necessary. Both these places are at 4 to 5000 feet above the sea, and at lower positions in Mexico the grape is not grown.

Eastward the whole border of the high plains of Texas affords fine wild grapes, and they are particularly abundant in the latitude of the Canadian river from the mountains east of Santa Fe to the humid district bordering the Mississippi.

XV. CLIMATOLOGY OF CEREAL GRAINS AND GRASSES IN THE UNITED STATES.

The cultivated cereal grains and grasses are all exotics, except Indian corn, and all come to us through the cool and humid equable climates of the west of Europe. For this reason their most successful districts are in the cooler parts of the United States, and we have yet nothing which will bear the heat of the southern States for the summer, the grains ripening before it comes on, and the grasses being destroyed by it. In France there are some forage plants, the lucerne and its associates particularly, which bear the warmer climates where the English grasses fail, but we have yet no success in transplanting them to our warmer localities. All the cultivated grains are capable of so great a range by a proper adjustment to the earlier or later months of the period of growth that the climatological limits have no definiteness on the tropical side, geographically, though they may have definiteness in actual temperatures for the months of growth. Wheat and barley are extreme in actual geographical range, both growing at no great altitude above the sea at the borders of the tropics, and wheat going to latitude 60° north, while barley goes to the Arctic circle. Oats are nearly equal to wheat in their range, but the minor edible grains and "fodder corns" for which the climate of the west of Europe is so well adapted, are here much restricted, and probably much neglected also. The various forms of millet appear to have a natural adaptation here, but they are little cultivated, either in the low forms of the north of Europe, or in the sub-tropical species which verge on the sugar cane, and are of vast importance in India. It is noticeable that the native cereals of the American climate approach the tropical forms to the exclusion of others, and are all sub-tropical in fact. Indian corn, rice—which in its wild state is much like the grain of the cultivated rice,—the native millet grasses, native canes, &c., exemplify this statement. The west side of the continent only affords some approximation to the high graminaceous forms from which the European bread grains are derived.

Notwithstanding the great possible range of wheat and the other

grains, there is much either in the local climate or soil which controls successful cultivation on the ample scale which the demand for the bread grains requires. There is also a valuable positive limitation on the side of low temperatures which may be defined at the outset, and it is remarkable that some of the localities of most abundant production of wheat lie very near the cold borders of the whole district, as in the case of Indian corn in the United States. In central Russia near Kasan, in the Baltic districts, in the British Islands, and in the Canadas, the capacity is most fully tested for commercial purposes, and the most ample quantities are grown. Probably the plains of the Saskatchawan, and the Pacific coasts at Puget's Sound and Vancouver's Island, will furnish similar districts. In England the value of a crop of wheat is probably greater on any definite area than in any other part of the world, except California, yet half the island is too cool for it, and a slight depression of the temperature for one ripening month will greatly reduce the quantity, or prevent ripening altogether. The summer of 1853 in England was nearly 2° below the mean, and the deficiency in the crop in consequence was one-third to one-half of the average. For the months of July and August the mean was at 57° to 59°,—the mean of 60° for these months being essential to a good crop. In the humid climates of the north of Europe the limit has a very small range, between 56° and 61° for the two warmer months; it is probably the same on our Pacific coast, though there is much more variability in the localities, some going even lower than the English, and others doubtless much higher for the limiting point. In both these districts the simple mean temperature is controlling, but in the interior of both continents the growth is limited by frosts rather than by average temperatures, and the summer heat at which it ceases to grow is from three to five degrees higher. There is some approach to a rule which would limit the growth of wheat on the west coasts at a mean temperature of 57° for the two months July and August, and at 62° to 65° for districts in the interior, as on the Volga in Russia, and on the Saskatchawan and St. Lawrence in America.

In regard to the greater districts of actual cultivation for commercial supply, geological structure and soil are controlling, perhaps, but a somewhat higher temperature than that before indicated is required, or a mean of nearly 68° for the two months before named. In Europe the vicinity of the Black Sea in southern Russia, and in Moldavia and Wallachia, is the first in natural capacity; that of the Baltic is next, occupying the best parts of the plain of the north of Germany; and the east of England next,—though this last may be naturally quite as good as the Baltic districts. In the United States, the corresponding districts are central New York, a large share of Pennsylvania with

part of Maryland, and a belt in the line of States bordering the great lakes on the south, and including the plains westward from Lake Michigan. These preferred districts have a mean temperature of 68° to 71° for the summer, and the harvesting month is July, or it may rarely reach the early part of August. In the cooler districts above named August is the ripening month, and in England a part of September is usually included.

In these districts the nearest approach to equable and cool summers, with an equable winter also, affords the highest measure of productiveness on the proper soils. Local excess of humidity in connection with high temperatures is much more injurious than when the measure of heat is low, and an unfavorable soil may exaggerate climatological disadvantages on the side of too much water. A high measure of heat may be borne if the air is relatively dry, with only the effect of shortening the period of growth, and ripening the grain so much earlier.

The immediate valley of the Mississippi from the Gulf to central Iowa, and along the Ohio to Cincinnati, is too humid and tropical for wheat; most of the low prairies and woodlands of the States bordering these rivers are also unfavorable for the same reasons. The interior is more decidedly so marked than the Atlantic coast, since only the alluvial plain south of Norfolk is unfavorable, the upland districts of the Carolinas and Georgia producing good wheat, though much less in quantity than on an equal area in New York.* Near the Pacific there appear to be no climatological limitations in the cultivable districts, and when all the conditions are favorable the quantity grown on an acre is far greater than in England.

The immense range of localities both here and in the old world influences the date of growth and the ripening period mainly, changing these from a full year as in England and in our own coolest districts, with a harvest in August or at the first of September, to a growth in the winter only, and a harvest early in May.

The limiting temperatures in wheat cultivation have been named in general terms, and a reference to the principal tables of the work will suffice for most of the purposes of this citation, referring here only to the mean for the ripening months at some of the representative localities. It is noticeable that the months of actual growth and ripening differ very little for the whole range of climates, the change being in the position these months have in the year.

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* The natural capacity of the country bordering the alluvial plain of the Carolinas for wheat may be inferred from the reference of Drayton and others to the splendid mills erected between 1790 and 1800 at several points on streams near Camden, and at other places along the line of the first considerable ascents. On the introduction of cotton and its associates they were abandoned, and the commercial staples have probably now reduced the capacity of the soil for wheat. (Drayton's South Carolina.)

Months of growth and ripening of Wheat and like Grains in the United States and Europe.

	Apl.	May.	June.	July.
	°	°	°	°
Gettysburg, Pa.	50.3	60.6	69.2	74.
Rochester, N. Y.	44.7	56.1	65.0	69.9
Oberlin, Ohio	48.1	59.4	67.6	75.5
Milwaukee, Wisc.	40.7	51.3	64.8	69.8
	Mch.	Apl.	May.	June.
Chapel Hill, N. C.	51.1	59.5	67.3	74.7
Athens, Ga.	55.0	64.0	69.1	75.4
Nashville, Tenn.	49.4	61.9	68.3	76.5
Ft. McKavett, Tex.	57.4	66.2	72.2	74.9
Sacramento, Cala.	53.2	59.5	65.2	71.7

	May.	June.	July.	Aug.
	°	°	°	°
York, England	57.0	61.2	62.4	63.5
Aberdeen, Scot.	52.3	56.7	58.8	58.0
Epping, England	56.6	60.0	62.2	60.9
Dantzic, Baltic	52.1	59.3	63.6	62.9
Konigsberg, "	51.9	57.4	62.6	61.7
Moscow	54.4	62.4	66.4	63.1
Kasan, Russ.	51.5	61.3	64.8	60.8
Bucharest	56.3	62.5	68.1	65.2
	Mch.	Apl.	May.	June.
Beyrout, Syria	61.3	65.3	71.3	75.4
Alexandria, Egypt	62.2	67.0	70.3	76.2
Palermo, Sicily	54.0	58.6	64.8	71.2

In the warmest of these climates the grains ripen in May, and at a mean temperature of 70° on the average. In the warmer interior climates where the winter is cold the ripening month of July is warmer, and in the cool districts of the west of Europe it falls nearly to 60°—requiring a much longer period of growth, however. There are three months of difference between the ripening dates in Egypt and in England on the eastern continent; and the same between the west of Texas and the elevated districts of New York for the United States. For the winter the absolute temperature seems not particularly important, unless accompanied with circumstances assisting to destroy the vitality of the plant, or starting it into too rapid growth. It remains without stem in the southern climates at higher temperatures for these months than it would so remain in the north, according to the rule by which vegetation at the borders of the tropics has a dormant season though the winter brings us frost. The period required to send up a stem and ripen the grain is much less in the warmer climates than in England.

Single cold extremes injure wheat only when heading, and such injury is sometimes experienced in all the elevated parts of the United States. It is probably the same in central Europe, though never occurring in the west of Europe, or on the Pacific coast here.

These statements throughout apply to barley, oats, and other small grains in similar terms, except that these, with rye, go into colder and more humid climates by nearly 5° of mean temperature. They everywhere bear cooler summers, poorer soil, and a shorter period of growth. Barley is the most flexible of all, ripening its grain in the short summer at the Arctic circle on the west of Norway, and going nearly as far on the Mackenzie's river in America. In mountain regions it forms a bread grain where all others fail, and this only by conforming to a more limited climatological requirement. Oats are more flexible toward the cool humid climates than wheat, but less so in regard to absolute frosts, not bearing freezing at any stage of growth. Rye goes somewhat farther in cool and dry climates than wheat, and upon thinner soils.

There is much interest in the positive facts respecting the distribution of these grains as economical questions, but the climatological restrictions are few for the temperate latitudes. On the cold side the mean of the ripening months must not be less than 58° for the most equable climates, and 65° for the variable ones; and at least two months must be free from frosts. In the warmer ones outside the tropics the only positive requirement is a period of growth free from humid tropical heats. Where these intrude into the cooler zone, as along the Atlantic coast to Norfolk, and over much of the interior plain below Cincinnati, wheat cannot be grown. The greater part of the United States is liable to these extremes as temporary conditions, and they are the principal climatological source of injury—originating rust, mildew, and proba

bly the injury which in southern Illinois sometimes renders the grain unhealthy as food.

It is remarkable that wheat goes far down Mackenzie's river in British America; Richardson states that "it is raised with profit at Fort Liard, lat. 60° 5′ north, long. 122° 31′ west, and 400 to 500 feet above the sea. This locality, however, being in the vicinity of the Rocky Mountains is subject to summer frosts, and the grain does not ripen perfectly every year, though in favorable seasons it gives a good return." (Arctic Expedition.) The same author cites various localities southward from this at greater elevations, where a precarious cultivation exists, endangered by the frosts of early summer more than anything else. It may be limited at the west before reaching Sitka, lat. 57°, but the greater area of the part of the continent embraced by the isothermal of 65° for the summer on the plains, and by that of 60° on the Pacific coast, will produce wheat in great abundance. A line drawn from Thunder Bay on Lake Superior to the Mackenzie at the 60th parallel, and from that point southwest to the Pacific coast at the 55th, would include an immense region adapted to wheat and the bread grains with only the local exceptions of mountains and worthless soils. It is similarly interrupted on the most cold and elevated uplands of the northern States and Canada, and for all the cooler localities of much elevation north of the 42d parallel the wheat grown is sown in spring instead of autumn. The difference is scarcely one of variety, since the sorts customarily sown may be converted from one to the other very readily, yet the ripening period is thrown forward nearly a month in the spring sown wheat.

Much of the necessity for spring sowing is due to exterior facts of climate, to an excess or deficiency of snow, or to something in the winter severity destructive to the plant. It is a striking proof of the hardiness of wheat that it may remain dormant four or five months under a moderate covering of snow without injury, and the advantage of the winter period may also be the same where but two or three weeks of a partially dormant condition occur, without snow, and at relatively high temperatures. A closely packed mass of snow which excludes the air is quite certain to kill the wheat, and severe freezes occurring in succession when it is without a covering do so. On tenacious soils the frost acts mechanically to kill it by drawing it from the ground, and each of the causes named produces great injury in the northeastern and central States, at frequent intervals.

The grasses are nearly equal to the grains in economical importance, and nearly all the cultivated forms are derived from Europe. They find decided limitations in the climate consequently, and are very far from supplying the full requirement here. Cultivable grasses are needed which will bear a higher summer heat, and the summer aridity which is so general in the districts now occupied by native grasses only, which yet show no adaptation to the necessary re-seeding and frequent change required in all cultivated districts. The *cultivable turf*, made up of some of the many varieties of grasses, belongs most decidedly to the district of equally distributed rains above the 39th parallel, and it is rare from Baltimore to Washington unless carefully preserved, as at all points near this latitude east of the Mississippi river. Within the area north of the 39th parallel there are many limitations, and it may be more precisely set down as co-incident with the heavy mixed forest—failing where that fails, either on sandy tracts or prairies. For the sandy plains of New Jersey and in some parts of New England the English grasses fail, though the cause is not climatological. But on the prairies of some of the States east of the Mississippi the climate assists to limit them through high summer temperature and long periods of drought. West of the Mississippi the climate is still less favorable, and as the soil has less of the retentive character in receding from the Mississippi, the favorite *cultivated turf* almost wholly fails. This turf is made up of a large number of species in the better grassed

districts, yet they are not generically peculiar; each of the leading forms or families furnishing species which go into the most arid and scatteringly grassed districts with equal facility. The millet grasses, and all species of the paniculate class, are remarkable for this capacity.

There is no part of the United States equal to England in the number and excellence of grasses, native or exotic, and in the best parts of the northern States for the permanence and luxuriance of summer grasses the winter is sometimes so severe as to kill them outright. It is doubtful whether there is any precise limit of temperature at which this occurs, yet it is certainly only at temperatures much below zero. This degree of depression occurs sometimes for days together in the upland districts at the north,—in New York, Maine, Vermont, and New Hampshire, with Canada and perhaps the northern parts of the western States,—and it is only in such localities that the destruction of the grasses occurs at these latitudes. At Washington, however, the anomaly is presented of absolute destruction of the cultivated grasses both by the cold of winter and heat of summer. On the whole Atlantic plain at this latitude the cultivated English grasses are with difficulty maintained, though the defects of soil on all this plain, with most of the eastern slope of the Alleghanies,—where retentive clays alternate with loose sands, all destitute of vegetable matter,—much exaggerate the climatological disadvantages.

In the middle States there are several valuable species of blue grass (*poa*), the best growth of which is in the States bordering the Ohio river, particularly in Kentucky and the southern part of Indiana. Dr. Darlington ranks the blue grass (*p. compressa*) first even in Pennsylvania, and Ruffin remarks that "it bears the hottest summer in Tennessee and is there best," while it "affords luxuriant winter pastures" as far north as Indianapolis.* These species prefer calcareous soils, and they do not appear to be adapted to the prompt seeding and ready cultivation which are so necessary to a varied agriculture. With so many points of value where the English grasses fail, the capacity of the blue grass for prompt turf formation by seeding should be thoroughly tried. It spreads with sufficient rapidity from the root for permanent pastures.

Next to these on the south there is a large number of sub-tropical *sorghums* or millet grasses; the gama or sesame-grass (*tripsacum*), Guinea grass (*holcus*); Bermuda or Dourra grass (*cynodon dactylon*), said by Lindley to be "the most common India fodder-grass," and others. These are strong succulent growths, and mostly from the tropics. On rich lands they form turfs, with a very abundant growth, which it is difficult to preserve, however, or to adapt to frequent ploughings and field cultivation. The sugar cane is itself frequently cultivated as a grass with success; and all these are more easily cultivated as forage plants, to be used for pasturage and soiling only, than as dried in the form of hay. The succulent character of the growth scarcely permits curing, and the mixture of "winter grasses," or the coarser festucas often cultivated there for their winter's produce, of which the gramma grass and the technical "winter grass" are the principal, will ultimately be necessary to answer the end proposed in their grass cultivation, and indispensable, indeed, to their agricultural prosperity. In lower Louisiana one of the native canes, *arundo aquatica*, covers the marshes with a very rich growth on which cattle fatten in the winters until it is cut down by frosts. It is more easily destroyed by frosts than the other species of *arundo* or *miegia*. A still smaller form of *arundo* forms a tall grass on the Arkansas bottoms. The native southern grasses, with their congeners which have been brought from other countries,

* "In the timbered counties south of the Wabash, where the settlements were made in early times, and the farms are highly cultivated, the capital of the farmers enables them to compete in cattle raising with the northern counties, especially where, as is the case in Montgomery, Putnam, and some other counties, every inch of woodland is thickly set in blue grass, affording luxuriant winter pastures." (*Indiana Journal.*)

though rich and succulent, are diffcult to cultivate, and the species which will grow on exhausted lands are only the worst forms of the families named, mainly of joint grasses, and they often prove pestilent weeds. The "abhorred crab-grass" or crop-grass, is one of the worst of these.

Next to the middle and southern States on the west, the dry plains afford some very valuable native grasses, the best of which are the several varieties of *grama** as they are generally termed. Those of the largest growth have been tried with success in many parts of the south, and for the dry, upland districts they will certainly succeed if the soil is well kept. At least six species of *chondrosium* have been distinguished, all of which are ranked as very valuable over several degrees of latitude on the plains, forming a belt central at the 35th parallel, and beginning at the meridian of 98° west. Capt. Marcy remarks that they flourish best at lat. 30°, the larger species going to 36°, and the Buffalo grass, according to Fremont, at least to lat. 40°. In Texas and New Mexico the term "mezquite" is applied to the grama, apparently from its general association with the shrubby mezquite trees of the hills and elevated plains. The peculiar value of the grama is found in its adaptation to all the requirements of an arid climate; it grows in the rainy season whether that occurs in spring, summer, autumn or winter; and it is singular that its native range embraces an almost distinct rainy season at each part of the year named. West of Arkansas the rains are in spring; in northern Mexico, not far from the Rio Grande, in summer; in the southern parts of Texas and New Mexico in autumn; and in the north and west of New Mexico mainly in winter. Whatever the period of growth the plant seeds profusely as the dry season comes on, and the leaf and stem retain most of their nutritive matter in drying, forming superior feed for all grazing animals as long as the dry season lasts. This peculiarity is much remarked upon by all officers who have traversed the plains, and every one bears testimony to its superiority over all other grasses of dry climates.

It is not easy to identify any single valuable species among the native grasses of the great northern plains. The rich blue grass goes to the 43d parallel, perhaps, in open woodlands, but the great prairies have many peculiar native species of most tenacious hold until the turf is broken, but then almost incapable of reproduction, as they rarely produce seed and never spread from the root. The loose black soil of the prairies up to the 42d parallel is very difficult to cover with social grasses when once broken, and the English grasses succeed only at the border of marshes, where it is decidedly moist and tenacious. These prairies are more richly and variably grassed in British America, and they doubtless merge gradually into the humid climates and tenacious soils both east and west of the plains above the 49th parallel.

On the Rocky mountains and westward the "bunch-grass" prevails everywhere until the humid climate of the immediate coast is attained;—the species are named as *festucas* usually, yet often identified with the grama, which last, though somewhat similar to the festucas, is generically distinct. They appear to be paniculate grasses of more free growth than the grama of the eastern plains, yet generally assimilated, at least so far as regards climatological adaptation and nutritive value.†

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* The preferred generic term is *chondrosium* (Torrey), though Nuttall designated it *atheropogon;* and Torrey also changes the *sesleria* of Nuttall (Buffalo grass, or small grama) into *chondrosium.*

† Fremont remarks of the value of these indigenous grasses, as found in his earlier expedition to the Great Basin and to Oregon: "The grazing capabilities of this region are great, and in the indigenous grasses an element of individual and national wealth may be found. In fact, the valuable grasses begin within one hundred and fifty miles of the Missouri frontier, and extend to the Pacific ocean. East of the Rocky mountains it is the short curly grass, on which the buffalo delight to feed (whence its name

Near the Pacific at the north the English grasses are perfectly naturalized, and at the south, in California, the very variable local climates produce or require almost everything in turn—oat grasses, and the heavier seeded native paniculate grasses—native clovers, the *medicago*, and associates of the lucerne, with various annual forage plants of the transition climates. Leguminaceous forage plants are abundant in California, both native and exotic; and through all the eastern and southern climates they grow profusely, as if among the best in natural adaptation. The "wild pea-vine" adds very largely to the forage supply in the Mississippi valley, though giving way on being pastured, and probably not worthy of cultivation. Vetches would grow profusely, though now scarcely introduced. At the south the smaller peas are largely and profitably sown for forage or stock feeding on them when ripe, and the soils which there suffer so much from exposure and washing might often be covered with a valuable growth of some of these leguminaceous annuals.

The more important cultivated clovers correspond very nearly with the cultivated English grasses in their range and requirement, the large clover being killed sooner than the grasses on wet soils and in severe cold, and going into warm climates a little farther. At Washington red clover is more easily grown than the timothy grass, yet it does not stand the hot summer well. The same results are found on the western prairies at a higher latitude. The lucerne and other forage plants of the south of France are also very precarious south of Philadelphia from the heat, and equally so north of this point from the severe cold.

As a whole the American climate is singularly favorable to the making and preservation of hay, or dried grasses,—the natural hay of the plains being unparalleled, indeed. The long winter in the eastern States requires a much larger preparation of hay than the English climate, and the summer is much more favorable than that of Europe for this preparation. With the occupation of the prairie districts, which are unfavorable to hay-making generally, the relatively small area where the English grasses may be grown in abundance will be fully occupied for such purposes. The climate of the grazing districts at the north has repelled their best development, but they form so small a share of the whole area of the United States as to already exceed the grain growing districts in importance.

The grasses characteristic of arenaceous districts in the North and in Europe are very important in the economy of cultivation and in the reclamation of sea sands. In many localities on the North Atlantic coast they will be required to arrest the march of sand dunes, as in Holland, and on the English coast. But, as said before, their characteristic differences belong to soil rather than to climate; and, so far as known, the varieties used for that purpose would be of little value on the sandy plains of the interior. The grama grass approaches nearest the qualities desirable there, and its distinctive adaptation is not to arenaceous soils merely nor mainly, but to the dry atmosphere and small amount of rain found in those districts.

In some parts of Virginia an arenaceous grass of considerable value is found, but no attention has yet been given to the adaptation of these forms to our interior sands.

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of *buffalo grass*), and which is still good when dry and apparently dead. West of the mountains it is a larger growth, in clusters, and hence called *bunch grass*. This has a second or fall growth. Plains and mountains both exhibit them; and I have seen good pasturage at an elevation of ten thousand feet. In this spontaneous product, the trading or travelling caravans can find subsistence for their animals; and in military operations any number of cavalry may be moved, and any number of cattle may be driven; and thus men and horses supported on long expeditions, and even in winter in the sheltered situations." (Report of Exploring Expedition, p. 277.)

XVI. GENERAL SANITARY RELATIONS OF THE UNITED STATES CLIMATE.

The principal purpose entertained in establishing a system of meteorological observation by the medical department of the Army was that of sanitary investigation in immediate reference to the health of the troops. In extending the military posts to the newly acquired territories at the south and west, and in keeping them at the exterior limits of settlement in all cases, as the control of the Indian tribes required, it was found that great differences of local climate existed, and that the south and west presented extremely severe forms of disease. Dense forests, swamps, and humid, unventilated valleys, were necessarily made posts in many cases; and the change in temperature from Maine and Lake Superior to the Gulf coast, gave opportunity to make a new and most comprehensive comparison of the new diseases with their climatological associations. Great exertions were necessary to preserve the army, indeed, under the rapid drain in these unhealthy districts, and inquiry into the climate was imperatively necessary as a guide to placing the forces. The results of the long series of observations, taken now for forty years, or since 1818, serve now to define the climate of every part of our territory as far as the measures of temperature and of the quantity of rain are concerned, but the more accurate observation of atmospheric humidity has never been perfected, and the element it gives is necessary to the purpose originally undertaken.

The observations now accumulated are all necessary to this sanitary investigation, however, and none of them could have been omitted. If careful hygrometric records could have attended these at the posts where diseases of the half tropical wilderness were most severe, and at points where it may now be comparatively healthy, it would be easy to say whether any change has yet occurred which those instruments can measure, and much light would be thrown on the class of diseases called malarious. Even where the greater constants of climate remain the same—the mean temperature, and mean quantity of rain—there may be local humidity which is dissipated by draining lands or removing forests, and the degree of these climatological excitants

to malarious disease may undergo considerable change. The dense half-tropical wilderness of the United States presented such advantages for the study of these relations as are found in no other parts of the temperate latitudes, and it is unfortunate that the early attention of the directors of this system of observation was not given to the registry of the wet thermometer.

But these observations have given an ample basis for the determination of the constants of temperature and of the quantity of water falling in rain, and as these suffer no change by the lapse of time, the geography of all generic forms of disease may readily be constructed in direct association with the geography of climate. The rude and general comparison which this gives is perfected at several points by careful observation of the temperature of evaporation as shown by the wet bulb thermometer, and outlines of the determinations made at such points may be extended. Several able authorities have discussed these relations,—Dr. Barton at New Orleans, Dr. Engelmann at St. Louis, Dr. Hunt at Buffalo, and others. This closer analysis belongs to the medical profession particularly, since the precise relations of disease to exterior causes involve intricate pathological questions, and the disputed point in regard to the existence of a specific malarial poison is one of these. Beyond this the grouping of climatological conditions in association with the classes or generic forms of disease may be made, as the suggestion of climatological research to the medical specialist.

So many years of observation in this sanitary purpose should have given some positive results in the mutual geography of disease and climate, yet nearly all the leading forms are variously distributed by different authors. Pulmonic affections have been assigned by recent writers as much to the tropical as to the cold temperate climates, in reversal of the doctrine previously held. The existence of specific malarial poison is controverted, and epidemics of the severer sort are asserted to be contagious in disregard of climatological conditions by some, while others hold the current climate to be controlling, and the infection to be its incident only. Yellow fever is the most important of these, and the public interest in ascertaining the true relations it has to climate can scarcely be overrated.

The statistics of disease and mortality should be compared with climatological statistics in the fullest manner, and for the country as a whole, with the diversity presented in the deserts and plains, and on the Pacific coast. It is yet too soon to do this however, and for the results of that class it would be instructive if not decisive to obtain statistics from the old world. But the constant accumulation of observations gives new opportunities in rapid succession and it must

soon be possible to make some decisive distinctions, and to identify all the exterior and general relations of climate to disease.

In the United States the greatest interest has been felt in what is by common consent designated the malarious class of affections. Fevers peculiar to the warmer months have been prominent at the first settlement of all parts of the country, and whether the doctrine of specific malaria be admitted or not, the definition of this large class as malarious affections will be readily understood. All the New World as known to Europeans previous to our entrance upon the arid plains, and the mountainous interior, has been distinguished for certain and severe disease to the unacclimated; and the European emigrant has only found it severer by a small degree than the emigrant from the older settled States of the east, where time and cultivation have removed local influences of a character similar to the exciting causes in the new States of the west.

It is now asserted that where these causes of disease are permanent the effects are permanent, or that there can be no acclimation to malaria,* and that the change which follows occupation implies a removal of the causes, and not an acclimation to them. Districts with a high degree of climatological tendency towards its development find malaria and malarious diseases constant; and only where the climate is but moderately warm and humid for the summer can the local or general unhealthiness in this respect be wholly removed by occupation and cultivation.

Every part of the eastern United States has had more or less of this local unhealthiness when first settled, the river valleys of New England presenting decided cases in their early history. In central New York it was for many years very severe and general, and not less so in Virginia for a long period. But the Mississippi valley has been pre-eminent as the theatre of malarious or continued fevers, and there they have been the scourge of the early emigrants from every part of the world. To the natives of the climates of the north of Europe, and of the British Islands particularly, the transition has been more severe than to others, and a prostration by some one of its forms, mild or severe, has been certain to attend the new comer. India itself has not been more certain to break the health of the emigrant than the Mississippi valley, though the American forms of disease were always attended with a much smaller ratio of mortality. It is impossible to ignore facts so great and general as these, and impossible

* Dr. J. C. Nott, on the influence of climate on the Human Race in acclimation, Hays' Medical Journal, 1856. Also the extended part by Dr. Nott in "Indigenous Races," on the same subject.

to avoid attributing this great condition to climate primarily; and next, to the effects of a warm and generally humid climate in local accumulation of excitants to febrile diseases of a distinct and definable class which may be designated *malarious*, whether specific poison of the sort defined by this term be admitted or not. For convenience of reference this term will be used as synonymous with intermittent, remittent, and autumnal fevers, and *malaria* as that of their specific excitant, or immediate cause.

Next is a class of zymotic diseases—epidemics and infections—which is intermediate between those of malarious origin and the fevers and pulmonary diseases of cool and moist climates. Some of these, and particularly the severest form known in the United States which is usually classed with these, yellow fever, have definite climatological relations which it is most important to trace out and define. Cholera may have such relations also, though they are now certainly obscure. Of the host of minor epidemic fevers and contagions it is difficult to say whether they have such relations or not, but all are worth tracing in this connection to see if even a negative is proved, and this may be as valuable a result as any other. The desolating *plagues* of the old world are the most mysterious and obscure of diseases of possible climatological associations, and their equivalents here may merely have more familiar names.

The pulmonic or respiratory class of affections is next to the malarial class, and these are undoubtedly the representations of cool and moist climates distinctively. The citations having an adverse show are numerous and much relied upon, it is true, but it appears too strongly supported by statistics to be longer a matter of doubt.

In an outside view of these classes we may now make some distinctions which are generally accepted. The malarious class belongs, as a rule, to all the humid climates in the degree of their temperature and humidity jointly for the summer months, if the attendant conditions of soil and vegetation exist in the usual relations to such a climate. Thus in traversing the Mississippi valley from the north the severity of malarial fevers increases from Lake Superior to the Gulf of Mexico, under average or like conditions. Sea air, naked sands, pine forests, and other local features, have great influence near the Gulf; and the nature of the malarious emanations is such as to permit a good deal of this sort of diversity, where the country on the whole is decidedly one of severe and almost constant malarial fevers.

As we occupy but little of the cool and equable climate of the continent as yet, that of the north Pacific coast being more particularly such than the northeastern provinces, the contrast of healthiness in this respect with Europe is apparently great. In Europe there was

never so large a proportion of alluvial tracts under so high a temperature, nor so much of what is expressively termed *bottom land* here, which is the great nursing place of malignant fevers. The unbroken forest belonging to the whole country of the eastern United States favored this accumulation of vegetable matter, and whatever may be determined in regard to the more precise character of malaria itself, it is certain that it belonged previously to these great peculiar conditions of the country, and especially to its new, unremoved vegetation, and to all associated with its high temperature and profuse rains. And when these local conditions change or are removed, we find the climate reproduce them again if permitted to do so; woodlands and profuse vegetation are reproduced, and with them come all their original associations.

It is too early yet to say what the precise measure of difference or kind of distinction is between the sanitary characteristics of the arid and elastic climates of the interior districts, and those of the central and eastern States. There is no doubt that they differ very much, and that they are peculiar in contrast with the eastern States and the greater part of Europe, finding their representatives only in Asia and the interior of the old continent. From the Mississippi valley westward the change is almost as abrupt as that from India northward to the basin of Tartary, and the west of China; the positions are only differently arranged in their relation to each other. Of the peculiar differences of half tropical and interior climates in their sanitary consequences we only know now that malarial fevers nearly disappear in the east, and that infectious epidemics are much modified, if not quite limited, in dry interior areas. Diseases of the respiratory organs, which give such a scourge to us in consumption, are also much less severe in the interior, and they apparently become of little importance in such districts. In short the severest forms of general disease now prevailing become very much less important, or fail altogether as the capacity for sustaining a dense population fails, since this capacity is itself a climatological consequence mainly.

All that can now be done satisfactorily is to show some points of the distribution of these associated conditions of health and climate, and this exterior discussion is a necessary incident of climatological investigation. Without the aid of clear distinctions of climate, Medical Geography, as it has well been designated by Johnston, is difficult if not impossible. Unusual attention is now being given to the collection of facts for this comparison, and more time is necessary to make them complete. There are many points of preliminary inquiry which it is impossible to attempt for want of these facts, and the discussion is now involved in much confusion from the discrepancies of the partial

and incomplete statistics that have been used because there were none better.

There is the same mingling of strongly contrasted forms of disease in the changing seasons of the United States as in everything else dependant on climate. The tropical forms go northward nearly to the 42d parallel, and yellow fever, the highest tropical form, has found a favorable local climate at various cities of the New England coast in several cases. In the cold season this, with all other severe malarial diseases, disappears from the entire area, and the forms originating in the sharp temperature changes of the cold zone are substituted. Though much has been written in the view that pulmonic affections are not due to cold climates distinctively, citing the great prevalence of consumption in the tropical countries of this continent, there is far more ground for regarding diseases of the respiratory organs as the natural antagonist of the tropical forms so far as the United States are concerned, and as induced at the south so largely by the intrusion there of the climate of the cold temperate latitudes for a part of the year. It is not the positive temperature, but the intrusion of great changes both of heat and humidity which constitutes the condition most opposed to tropical equability, and if this view can be regarded as correct, the diseases associated with consumption may be taken as the natural representatives of what we designate as the cold zone. For the space we occupy of the temperate latitudes they characterize the cold belt, as yellow fever does that most nearly tropical.

Intermittent fever, or fever and ague, which is one almost universal form of malarious disease, goes only to 45° of latitude, at Montreal; or with a few local exceptions a degree farther perhaps in the St. Lawrence Valley. Dr. Drake cites a few cases of temporary or local origin—originating in circumstances belonging to an unoccupied country—at lat. 46° on the south side of the St. Lawrence, and he concludes that it absolutely ceases from climatological causes at lat. 47° 30′.* The same authority cites a few cases of this distinctive disease at Sandy Lake, near the sources of the Mississippi, and at the 47th parallel. At the 45th parallel it begins to be abundant, and from this to the 40th it is much more prevalent in the Mississippi Valley than about the lakes and on the Atlantic Coast. Of the returns of intermittent fever at the military posts of Mackinac and Fort Brady, Dr. Drake remarks that most of the small number of cases appearing there evidently originated in lower latitudes, and he concludes that at Fort Brady, particularly, the climate annihilates the topographical influences which produce these diseases.

The summer isothermal of 65° is nearly at the northern limit of diseases of malarious origin along its whole course from the Atlantic Coast westward to the 97th meridian, or to the border of the arid plains. At this limit a much higher temperature is requisite to develop it, and at a certain limit of aridity, instances of it cease altogether. In the lake district and in the elevated parts of New York and New England the line

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* See Dr. Drake's very thorough examination of this subject, occupying a large space in his work on the *Diseases of the Interior Valley of North America*.

falls farther south, and excludes all districts of 1200 to 1500 feet elevation, but the average limit would be nearly at the 45th parallel.*

According to a recent and able essay on the Geography of Health and Disease by A. K. Johnston,† ague is endemic on the Gulf of Bothnia, beyond lat. 62° north, and in western Europe its limits include Scotland, and extend to lat. 62° 40′ in Sweden. This is somewhat above the limit of 60° mean temperature for the summer for the west of Europe, though Johnston represents such a temperature as necessary to its production, and that it will not become epidemic at less ~~than 65°~~ of mean temperature. "Farther eastward it sinks to a lower latitude, and in Central Asia it appears not to extend beyond lat. 55° or 57° north, forming a curve nearly coincident with the isotherm of 41° for the year. To the south of this, or from lat. 54° to 40°, at the level of the sea, and on the coasts and river banks, it constitutes one of the most prevalent diseases."

The greater humidity of western Europe carries this form of disease there to a latitude having a lower mean temperature than its limit here, if this statement of limits is complete, yet it is believed that between the parallels of 40° and 45° in the two countries there is greater frequency here than in Europe, and that, on the whole, malarious diseases are much more prevalent here than in Europe south of latitude 42°. The distinction would seem to be that certain localities in the south of Europe generate a more deadly and suddenly destructive malaria than any known in the United States, while the comparatively mild forms of intermittent and autumnal fevers are here so generally prevalent, that in many districts the whole population participates in some degree of the affection in a single year.

The second great sanitary division of humid climates is that of inflammatory and pulmonic diseases. This embraces all north of the 42d parallel in the United States at all seasons, and the whole area of the eastern United States, except the peninsula of Florida, for the colder three months. Johnston makes three divisions; one of Malaria and Yellow Fever, a second of "inflammatory diseases represented by typhoid fevers," and a third of "catarrhs and colds;" the last embracing the sub-temperate, sub-arctic and arctic zones in temperature. But there is scarcely any need of the three divisions in the eastern United States, since inflammatory fevers are directly associated with the severest part of the seasons here, and they give place to malarial fevers, cholera, and other half-tropical affections, only in summer. Dr. Forry makes but the two distinctions, for which climatological differences are responsible; those of malarial fevers,

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* The fact that there is now little or none of fever and ague in the Connecticut Valley and on the New England Coast is no disproof of its climatological adaptation to it, if local circumstances are favorable. Dr. Forry quotes from Dr. Holmes' Prize Dissertation on the Intermittent fever of New England proof that intermittent fever has prevailed on the Connecticut River from our earliest colonial history. Dr. Holmes also shows from historical evidence that fever and ague prevailed at Boston in 1761, and also at New Haven 'on its first planting.' Dr. Forry cites Dr. Williams of Deerfield Mass., as asserting that the locality there was once the bed of a lake, but subsequently, as marshes and meadows, was rife with fever and ague. "Within the last sixty-five years however few cases have occurred, and it is at present unknown,—a result ascribable to the gradual drying up of the marshes." The same writer cites Dr. Holmes' map of the distribution of localities of the prevalence of fever and ague—twenty-seven places being found in New England, and all at alluvial lands and marshes—and he infers that it is there always of local origin. The most important point in the present purpose is to show that climatologically it would be endemic as far as the limit named. If local peculiarities of soil or exposure adverse to it exist, its absence is due to these causes, or rather, it is present only where malaria exists.

† Johnston's Physical Atlas, edition of 1856.

and of pulmonic affections; though many others are more or less clearly defined in some relation to these classes. Pneumonia is most difficult to place, and much has been written on its distribution. It must be conceded that rheumatic affections have their origin in cold and humid districts, though doubt has been thrown on this point also, and the Army Surgeons find that when originated it puts in peculiarly aggravated forms in the half-tropical climates of the Gulf coast.

The arid climates of the interior and the cool Pacific coast have been occupied so recently, and so little observed, that it is difficult to trace the climatological geography of disease there, but enough is known to decide that malarious diseases are comparatively rare, and that their antagonist forms as observed in the eastern United States, or the pulmonary class, are almost unknown from California southward. Humidity is an essential element of each, and in its absence both disappear for all districts when the temperature is high enough to develop malaria. In what degree pulmonic affections reappear in the cool and humid climates of the North Pacific coast cannot yet be decided, for the reason that so little is known of the sanitary condition through statistics from a resident population. The probabilities are, however, that it is like the similar climates of the northwest of Europe, and that it will exhibit a considerable prevalence of pulmonic affections, along the coast of Oregon and northward.*

The remainder of the western region is almost free from one of the two great classes belonging to the eastern United States, the respiratory class, and in a great degree free from the malarious class. It is, on the whole, more favorable to health and energy, mental and physical, than any known portion of the continent elsewhere. Some further reference will be made to facts disclosed by the little knowledge we have of it through a resident population.

The class of most interest and importance here is that made up of malarial diseases, and the epidemics associated with them. Yellow fever is the highest form of these, and it can hardly be said to be endemic anywhere in the United States, though an epidemic somewhere almost every year, and a frightful scourge at intervals. In Berghaus' Charts of the distribution of Diseases† there is no yellow fever indicated for any part of Europe, yet in Botta's History of Tuscany mention is made of a deadly epidemic yellow fever at Leghorn, said to have been occasioned by "the prevalence during the summer of that year of south winds unusually warm and rainy." Johnston describes its epidemic range to have extended to several cities on the coast and in the interior of Spain,—"several times at Gibraltar, once at Rochefort, once at Lisbon, and once at Leghorn." It is properly an American form of malarial disease, with its home in American tropical regions, and it is somewhat singular that it is unknown in the East Indies and China. It is carried by vessels from the West Indies to all parts having commercial connections there, and it appears wherever the climate permits such communicated cases to spread.

In this manner it has been distributed as an epidemic as far north as New York in several instances, and nearly as often, at towns along the south coast of New England. In 1692 it is said to have prevailed at Boston, and again in 1798, when it also prevailed at Portsmouth, N. H., Newport, R. I., and New London. In 1800 and 1801 it was at Newport, Providence, and New York; in 1802 at Portsmouth and New York,

* Capt. Wilkes remarks the great prevalence of pulmonic diseases, particularly consumption, among the Indians near Puget's Sound, and the same facts have been noticed by others. But the habits and mode of life of these tribes are peculiarly favorable to the development of such affections.

† Physical Atlas. In Johnston's Physical Atlas, edition of 1856, a Yellow Fever region is defined in Europe, which embraces the Spanish Peninsula and the Mediterranean coast eastward to include a part of Italy.

and in 1805 general at these cities, with New Haven.* There has been much less of yellow fever at these New England cities now than formerly it is clear, and this exemption is mainly due to the better protection against infection, with the diminished commerce with yellow fever ports, and the removal of local sources of malaria. It is not probable that the climate has permanently changed there, or that there are not periods in which the summer heat and humidity would permit its prevalence, if once communicated.

Reviewing the records of its prevalence in the United States, it is found that it has nearly disappeared from New England, and become greatly milder and more rare at Philadelphia; but it is becoming almost constant at some points of the south in a moderate degree of prevalence, because the contact with points where it is endemic is constant. It is, however, never severe unless the conditions of climate or locality favor its development, and this is the case less frequently since sanitary precautions have been so well understood and enforced.

Yellow fever is thought by La Roche and others to be almost generically different

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* See La Roche's very thorough history of Yellow Fever in the United States in his valuable work on Yellow Fever, two vols. octavo, 1855. To the items given above the following resume of the history of yellow fever in the United States may be added, condensed from La Roche's work.

The first known instance of yellow fever was at Philadelphia in 1699, but seventeen years after the city was founded, and in the same year it prevailed at Charleston; though La Roche supposes that a nameless epidemic prevailing at Boston in 1692 may have been yellow fever. It prevailed at New York in 1702 (Dr. Bard), at Charleston, in 1703, and again in 1728, 1732, 1739, and 1740 (Dr. Lining). At Philadelphia it was very severe in 1741, and it prevailed more or less at Philadelphia and New York in 1741, 1747, 1760 and 1762; after which little or "nothing was heard of it for thirty-one years."

In 1793 a severe epidemic yellow fever again prevailed at Philadelphia, and in 1798 one still greater at New York, in which thousands perished. The last also reached to many cities of New England. In 1799 it was mild at Philadelphia; in 1800 more severe there, and general in New England; in 1801 very severe in New York; in 1802 at Philadelphia and Baltimore, with a few cases at the north; in 1803 at New York; in 1805 general at the cities before named. In 1820 a severe epidemic occurred, and from 1820 to 1853 there were moderate epidemics at various points southward and including New York. In 1853 the well known terrible scourge was experienced at New Orleans, and at various towns and cities of the vicinity; in 1854 Savannah, Charleston, and Augusta were devastated, while it was not severe at New Orleans; and in 1855 the still more deadly epidemic at Norfolk and Portsmouth concludes the record.

In Dr. Barton's valuable report on the Cause and Prevention of Yellow Fever, the epidemics of this disease at New Orleans are given as follows:—

Date.	Deaths per 1000 of Population.	Date.	Deaths per 1000 of Population.
1817	24.8	1839	10.9
1819	16.2	1841	16.8
1820	14.7	1847	21.3
1822	25.5	1848	7.5
1829	18.9	1849	6.3
1832	7.3	1853	52.6
1833	17.7	1854	15.4
1837	19.0		

In severity these are in the following order: severest in 1853, next in 1822, 1817, 1847, 1837, 1829, &c.

from other forms of malarial fever. In a very thorough examination of the point in the work before quoted, he shows conclusively that its pathology differs widely from any of those, and that it cannot be regarded as in this sense the direct culmination of malarious diseases of the milder forms ; but whether this is the case or not is unimportant to the present purpose of defining its climatological distribution. We find it to belong, like all those milder forms, exclusively to warm and humid conditions of climate, and to localities where vegetable and animal decomposition generate miasmatic emanations. When cultivation has cleared the forests and drained the marshes as over most parts of New England now, not only fever and ague, and the autumnal fevers once prevalent at many localities wholly disappear, but yellow fever becomes, apparently, incapable of being communicated. There is no other reason why the New England cities should now be exempt, while it is almost constant in the West Indies and the South, with a communication sufficiently frequent to transfer it at least as often as before. In the vicinity of New York tide water marshes are very numerons and they continue to generate great local prevalence of fever and ague. These localities have cases of yellow fever whenever exposed to communication, and will so continue, at the intervals of the presence of the requisite meteorological conditions, till the local causes are removed, though they are at nearly the limit of climatological capacity, and are liable to develop severe epidemics only at considerable intervals.

A feature of yellow fever noticed by the same author, which was strikingly exemplified at Norfolk in 1855, is its social relations, or cumulative character in a dense population. It is very rare out of towns even in the West Indies, and seems to belong to social aggregations almost alone. In these its virulence increases in direct ratio to the numbers, apparently, and the air becomes charged with a frightful measure of poison. Such was the case at Philadelphia in 1798, when Dr. Rush says that "there was something in the heat and drought of the summer months which was uncommonly enervating in its influence on the human body." There may have been error in regard to drought if he intended the degree of humidity of the air, for in the same connection the non-evaporation of perspiration is alluded to as a prominent fact with laboring men. At Norfolk a clammy and fetid moisture settled on everything, and at length swarms of "plague flies" made their appearance, indicating that the whole atmosphere was charged with poisonous and decaying animal matter.*

Dr. Barton's able report on the yellow fever epidemic at New Orleans in 1853 has

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* Rev. Geo. D. Armstrong, of Norfolk, (*Summer of the Pestilence*,) has given a description of this anomalous fly sufficiently definite for the present purpose, though its scientific distinctions are not yet given, it is believed. He describes it as "almost identical in shape with the smaller blow-fly, or shad-fly as it is sometimes called ; the posterior section of its body being longer and larger than the common house-fly,—the main difference between it and the shad-fly being in the texture and coloring of its wings, and in the color of the body. The wings instead of being transparent are opaque, and of a glossy bluish-black color, and the body, in the case of those I first saw, of an ochrey yellow,—in one I noticed on the morning I was taken sick, it was of a reddish orange. Its body and even its wings seemed to lack the elasticity of the shad-fly, and the insect itself was exceedingly sluggish, hardly flying at all, and very short lived. Within twenty-four hours after they first appeared I found many lying dead in the window sills." They were first seen August 31st, and increased in numbers to Sept. 5th, when they rapidly disappeared. Dr. Armstrong remarks their singularly rapid decay, and apparent diseased condition ; several inclosed in a vial for preservation wholly decayed in a very few days, leaving shapeless drops of animal dust. He thinks that they exist in small numbers at all seasons in hot climates, and that their abundance at Norfolk was due to the saturation of the air with decaying animal matter which stimulated their increase for the time.

shown the direct relation of this highest form of climatological disease to heat, humidity, and to the local malaria generated by organic decomposition. If either the meteorological or terrene causes are wanting there can be no severe epidemic, and only in case these causes combine in their highest form can any case of the disease be originated in the climate of New Orleans. It is yet unsettled whether infection gave the germ of the epidemic of 1853 there, but it is certain that it is within the power of any city of the United States, by proper quarantine regulations and sanitary precautions in the removal and avoidance of local malaria, to prevent the epidemic violence which our entire history shows may otherwise occur at least as far north as New York, and frequently at some one point among the entire list of exposed cities, or those of frequent commercial communication with the tropics.

The great range of conditions here, and the temporary institution of tropical features at midsummer, give the favorable occasions for these epidemics. Dr. Barton says of July 1853 at New Orleans: "The rains were now truly tropical not only in number but in amount, it having rained on eighteen days and four nights during the month." "Calms prevailed nearly one fourth of the month, showing the atmosphere to be in a stagnant condition, hot, saturated, and filthy. The gutters, twelve hours after a rain, reeking and bubbling up with gaseous products, all highly inimical to health." In August "there was but one day marked entirely clear, rain falling nearly every other day, and during the month reaching 7.016 inches." The number of calm days was without a parallel, and there was every "evidence of a close, suffocating, inelastic atmosphere."

But each of these months was less expressive of the change than the month of June of the same year, which was so truly tropical as to add greatly to the influence the subsequent climate had. Of this month Dr. Barton says, "The average humidity was .815, the average amount of moisture in a cubic foot had reached the large amount of 9.136 grains, or nearly three times the amount in January. The solar radiation became greatest at nine o'clock in the morning, which fact, with the almost daily showers, showed the tropical character of the climate we were now experiencing. The rains in May were about weekly; on the 9th of June constant rains set in, and fell almost daily through the rest of the month."*

The peculiarity of these tropical conditions does not appear so readily in statistics of average temperature as it does in such descriptions, for the reason that daily rains reduce the midday temperature, and the monthly averages, as usually derived. Such an increase of temperature really exists at New Orleans in these cases, yet it is much more likely to appear in averages at Philadelphia in a similar case. Thus for the months of 1853 named above, the mean temperature at New Orleans was lower for some portion of the time than usual, though in other parts of the United States, beyond the influence of the tropical rains, it was much higher. The following comparisons show this fact:

		June.	July.	Aug.	Sept.
		°	°	°	°
New Orleans, 19 years mean	by Dr. Barton	78 7	80.4	79.7	77.1
" 1853	by "	80.7	79.9	81.2	76.2
Cincinnati, 20 years	by Dr. Ray	71.4	76.5	74.2	65.9
" 1853	"	75.6	75.6	76.2	66.9
Philadelphia, 31 years	by Dr. Conrad	71 3	75.7	73.0	65 8
" 1853	" Dr. Swift	75.3	76.6	75.7	—

The average temperatures must be taken in conjunction with the quantity of rain, and the ratio of atmospheric humidity, in order to judge the entire condition fairly. La Roche indicates the mean of 80° for the period of its initiation, and prevalence as an epidemic, to be in all cases the requirement for yellow fever, and he supports this by the most ample and conclusive citations of authorities.

* Report on the Sanitary Condition of New Orleans, p. 23.

It is evident that the climate of many parts of the Mississippi valley is as favorable to the development of yellow fever as that of the cities of the Atlantic coast above Norfolk, and it is somewhat remarkable that none of the epidemics have gone farther north than Memphis. At this point a destructive epidemic prevailed in 1828,* but the traces have been slight or doubtful at all points northward. With the great development of local malaria at many points of the interior to the north of Iowa on the Mississippi, and to Pittsburg on the Ohio, as shown by the constancy and violence of autumnal fever, it is probable that such contact with it as is experienced in Atlantic cities—the fetid air of vessels direct from ports where it is prevalent, and violent cases so transferred—would institute as severe epidemics at St. Louis and Cincinnati as those that have prevailed at Philadelphia. The climatological geography of the disease points clearly to this conclusion, and if mistaken in regard to any of the agencies of its diffusion, it is better that such mistake should be on the side of precaution rather than the reverse. There are, it is true, some evidences that the interior of any country is less exposed than coast positions, though the experience of the world with this American fever is mainly with its diffusion by commerce beyond its original limits, which are the coasts and Islands of the Gulf of Mexico.

There is a class of local miasmatic fevers much more deadly than those that have been mentioned, yet probably differing only in degree. They are primarily climatological, but immediately due to the most poisonous form of malaria, or miasma, from swamps and marshes. Both the terms descriptive of the bad air of unhealthy districts originated in the designation of these localities as found in Italy and in other parts of the south of Europe, and they there occur in districts generally healthy, notwithstanding the deadliness of the precise locality. The substantial identity of all these forms appears proved by the fact that on the rice fields of the south, as at the Isthmus of Panama, the degree of exposure alone decides whether lingering ague and fever, or the more violent and suddenly fatal forms, ensue from exposure to these miasmatic localities. In one case the result does not differ from the ague of Wisconsin, where the malignant form rarely appears, and in the other it scarcely differs from the most sudden and deadly poison known. In South Carolina the planter spending a single night on a low rice plantation is struck with death almost inevitably, and the forms which the disease would put on if more mild, are lost in the sudden prostration of vital force, and are scarcely recognizable. The same danger occurs in crossing the Isthmus at Panama, in the Chagres, or Panama fever; and the case may be one of sudden death, or of variously prolonged fever or fever and ague; in the last case differing little from the fever and ague induced by residence near marshes in the vicinity of New York city, or among the sand hills of the healthier parts of Michigan.

In Italy this miasma is frightfully destructive to life, and Admiral Smyth remarks that "it is admitted by medical men that marsh fevers carry off or disable one-fifth of the dwellers along the Mediterranean shores."†

The deadly atmosphere of the Campagna and the Pontine Marshes is a matter of prominent record since the founding of Rome, and it is now even more conspicuous than when the prosperity of Rome was at its height. Of another locality a forcible instance is cited by Admiral Smyth, in which the French, by encamping near Baiæ, an unhealthy vicinity of Naples, had their army suddenly reduced from 28,500 to 4,100 men; and another instance is cited of the Russians in the Archipelago, near Paros, in 1770, where an encampment exposed to miasma resulted "in the death of the greater part of the soldiers and seamen, and the sickening of nearly all the rest."

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* Drake's Interior Valley, p. 134.

† Memoir, Physical, &c. of the Mediterranean, by Rear Admiral Wm. Henry Smyth, p. 226.

"To show how little Orloff's disaster" (that just named) "weighed with hygeian tacticians, I will just mention that so late as 1809 I served on the grand and powerful expedition to Walcheren, (Netherlands) where from precisely the same causes we lost 10,000 men, inflicted thousands of others with pertinaceous ailments, and utterly wasted twenty millions of money."* European history is full of these instances of terrible destructiveness to armies marched over or encamping on miasmatic localities. Smyth cites other instances, and particularly refutes the assertion made of many of these cases that they are *plagues*, in the sense of mysterious and unknown diseases. He insists that they are purely of malarious origin, and may be avoided by avoiding the localities where they originate.

La Roche has so thoroughly treated the subject of autumnal fevers, including the severer local forms known to the worst localities of Europe and Asia, that it would be presumption to attempt it farther, even in the simple purpose here entertained of showing the climatological distribution of malarial disease. In a most thorough and exhaustive chapter of the same work (Pneumonia and Malaria), *On the existence and Morbid Agency of Malaria*, he has demonstrated the simple and direct relation of all these diseases to actual *malaria*,—morbid and decaying matter in the emanations from stagnant waters and marshes, communicated by breathing and contact nearly as directly as when injected into the blood. And all the forms of malarial disease are shown to differ mainly in degree, though yellow fever becomes, in the opinion of the author, pathologically different, while differing little or none in regard to its origin.

In regard to the distribution of localities in Europe the following are among his numerous references. "The salt marshes of Normandy; . . the soil along the Mediterranean coast of France; the shores of the Adriatic, of Greece, and of Sicily; those of Sardinia, of Spain, of the Crimea; the lagunes of Holland from the Walcheren to Groningen; the soil of Flanders; the Pontine Marshes, and the Campagna in the vicinity of Rome; the maremme of Tuscany, Lucca, and the Mantuan; the soil of the vicinity of Camargue, . . Rochefort, and other parts of France; the alluvial districts of Algiers; . . the river banks and low flat surfaces of Hungary; the morasses of Upland, the plains of Scanea, Sudermania, and Gothia;—all present some of the characteristics pointed out, and all are, at particular seasons of the year, and under certain atmospheric conditions, the seat of febrile affections." The boundaries indicated by these citations, except in Sweden, would be within the temperature limits of autumnal fever in the United States, which is at a mean of nearly 65° for the summer for the most northern positions.

The climate of the United States is particularly favorable to the development of distinctive *miasma*, and where marshes exist it must be anticipated and guarded against. All the low country of the south Atlantic States has these localities in abundance, particularly as its rivers spread very much in lagoons and shoals, and rarely enter the sea by deep water channels. The basins and bottoms bordering the Mississippi and reaching even above St. Louis, are fruitful sources of miasma in the hot season, yet the degree of it is certainly much diminished at so high a point as that named. In all the Mississippi valley, indeed, Dr. Drake admits no other division than that of *degree* in regard to autumnal fever, characterizing the severest as only more malignant than the average. Perhaps if the marsh fevers of Europe were better known they would be found to be quite the same, and the great disasters recorded would be found to result from the sudden crowding of masses of unacclimated persons on the worst localities. More should be known of the malarious localities of the severer sort in the southern Atlantic States. It is sometimes stated that a narrow border of forest protects residences adjacent to these swamps perfectly, and that the

* Smyth's Memoir, p. 228.

removal of these, or other apparently slight causes, will bring the most severe and fatal consequences.*

The ague and fever blends everywhere with the localities of the most deadly miasm, and other writers than Admiral Smyth attribute the destruction of the British army in the Netherlands in 1809 to ague simply. As understood in the United States, or as the disease prevails here, such a result could hardly ensue, as the ague is usually if not universally taken to be an indication that a fatal fever will not supervene. Johnston refers to destructive epidemic agues in Europe, one of which, at Bordeaux, in 1805, seized 12,000 men, and proved fatal to 3000. It is endemic over the Netherlands and lower Germany, and generally over alluvions and river valleys, with marshes and stagnant water, in all parts of Europe south of the line before indicated.

In regard to all this class, though the climate is an immovable element and agency, it is never conclusive without the local source, and this is always within the control of man. As Dr. Barton has well insisted, this twofold agency permits us to control the result by the proper efforts, and by a proper definition of the climate so that

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* La Roche (Pneumonia and Malaria, p. 278, &c.) cites a number of cases of great interest in regard to the protection afforded by trees in such cases, which may be condensed here mainly in the author's words.

"Lancisi states that a thick forest formerly extended on the south side of Rome, protecting it from the effluvia of the Pontine Marshes; this belt has since been removed, and the country has become proverbial for its unhealthiness. . . Trees were planted by the Romans to protect localities in this manner, and the practice was enforced by law. 'Whole families,' says Bartlett, 'have resided near the Pontine Marshes, and, by the intervention of shrubs and trees have escaped for years the noxious effects of the mephitic vapors which these putrid waters engender.' Dr. Hosack states that a family in New Jersey was attacked with fever in consequence of cutting down a wood that separated them from a morass in the neighborhood. 'Army physicians therefore recommend,' says Dr. Wilson Philip, 'having a wood if possible between marshy grounds and an encampment.' . . Beyroot, formerly very unhealthy, has ceased to be so since the Emir Fakr-el-din planted a wood of fir trees, which still exists, a league below the town. . . 'The town of New Amsterdam, Berbice, situated within musket shot to leeward of a swamp extremely offensive at a certain stage of dryness, owes, evidently, its ordinary exemption from fever to this cause,'—the intervention of lofty or large trees. 'A still better instance of the same and with the same results, may be seen at Paramaribo, the capital of Surinam, where the trade wind that regularly ventilates the town and renders it habitable, blows over a swamp within a mile of the town, which fortunately for the inhabitants, is covered with the same description of trees.' . . M. Carrière, in a work on the climate of Italy, remarks that leaves act chemically to neutralize the malarial poison by emission of oxygen and says, 'Hence, to cover the fields, the edges of marshes, and the whole extent of the soil with an abundant vegetation is equivalent to placing on the surface of unhealthy regions a reparative apparatus of the greatest power.' 'Trees, therefore, must have a large share in the amelioration of the country in consequence of the quantity of leaves they furnish.'"

Several forcible instances of the deadliness of this miasm are related by Olmsted in a recent work; in one case a party of six, accidentally detained one night on a coast island near Charleston by loss of a boat, lost four of their number within a week after, and the remaining two suffered severely. In another case a planter remained a few days too long on the plantation where he had safely spent the winter, and died suddenly at the first decided appearance of the miasm.

Lieut. Maury has, still more recently, interposed a strong growth of annual vegetation between the National Observatory buildings and the shoals of the Potomac at Washington, with eminent success in diminishing the unhealthiness of the locality.

the dangers may be correctly estimated. Yellow fever rarely originates in the United States, and though malignant autumnal fevers undoubtedly do so now, proper drainage, occupation, and cultivation, divest them of malignity. In many parts of central and western New York malignant fevers were prevalent when the country was first occupied which have now disappeared, and they are so disappearing over much the larger portion of the western States where, ten, and twenty years since, they were constant and malignant. We have seen that the climatological limit is near us both at the north and at the west, and it cannot be doubted that a few years will greatly alter the estimate we have of the healthiness of the Mississippi valley, permitting, as it does, an unusually complete drainage of marshes.

The fixed conditions of climate will reproduce such unhealthiness, however, if not guarded against, as the Campagna of Rome and the Maremma of Tuscany have, after once being made salubrious by cultivation, become again almost as pestilent as when Rome was founded. Dr. Barton strongly sustains the view that yellow fever is initiated by extreme conditions of heat, moisture, and local malaria. In support of his views that even infection has little importance in comparison with these atmospheric and local agencies he makes the following forcible remarks: "Egypt, the Campagna or Pontine Marshes, Walcheren and Chagres, have each their peculiarities, but afford no argument in exception to the principles laid down, as I proceed to show. The cause of the diversity of the types of diseases in different climates medical investigation has not yet fully developed. Of that large class denominated fevers—the main outlet of human life, varying, in the estimate of eminent men, from one-fourth to two-thirds—the mystery may be more nearly solved than is generally imagined. The plague in the east, the yellow fever in the west, and the typhus gravior in England, are, by general consent, at the head of their respective classes in these great ranges of country. These climates differ essentially, not more in their temperatures than in their hygrometric properties, and in the mode of living of their respective populations. The climatic details are too limited in relation to Egypt to apply fully this mode of accounting for the plague, especially there, though two facts are well known in relation to the influence of causes readily arresting it. 1st. It is speedily put a stop to by the prevalence of dry winds from the desert. 2d. It is drowned out by the supervention of the Nile. An instance is mentioned where this was so remarkable that five hundred less died of the plague the day after an occurrence of this kind than the day before.

"The same principles apply to Walcheren and the Pontine Marshes, the insalubrious condition of both derive their controlling influences from their excessive humidity, though their temperatures are too low to produce the development of yellow fever.

"Although it is not entirely true that yellow fever is confined to sea ports, as supposed, or to places near the sea, yet it is uncommon for it to break out or spread much in the interior. Nevertheless it is well known, and experienced practitioners will bear me out, that sporadic cases do sometimes occur far in the interior when aggravated conditions of heat, moisture and filth exist in adequate combination to furnish sufficient cause. Thus it has occurred at Natchez, Woodville, Bayou Sara, and at other places on the Mississippi near the Gulf, and insulated places far in the interior where it was absolutely *impossible* for it to have been conveyed or imported, none being in New Orleans at the time, nor, as far as we know within 500 or 800 miles."*

The probable identity of the plague as known in Egypt and India with the higher forms of climatological or malarious disease, deserves an extended examination, but

* Dr. Drake remarks that "In the larger towns of the sugar zone yellow fever is, *apparently*, an endemic disease, and beyond that limit an occasional epidemic." (Interior Valley, vol. 1, p. 215.)

as no identified form of it has ever been known in the United States it may be passed over here. Johnson cites many proofs of its malarial origin; its point of constant prevalence being the Delta of the Nile, and other points of the eastern Mediterranean. At intervals it spreads to nearly every part of Europe. "Like the yellow fever, it is limited to the lower portions of the earth's surface, the more elevated situations being exempt from the scourge." "During the great epidemic plague of 1835 the Egyptian regiments encamped in the desert escaped almost entirely, notwithstanding the maintenance of constant communication with the capital and other places where it committed the greatest ravages."

Cholera is more obscure in its climatological relations than any other disease of similar violence, and what its associations are it is very difficult to say. There seems little limitation in the whole range of climates; if we disregard the contrast of seasons, which have a general effect, though by no means a uniform and reliable one, there is a wide range of position in the temperate zone which have shared its ravages. Among the most singular instances have been the fatality among travellers on the high half-desert plains on the overland route to California, and that at elevated cities—Chihuahua and El Paso—in northern Mexico. In these otherwise extremely healthy localities it was for the time as destructive as in the densely populated cities at sea level. It has often been violent in the cooler months, though in the United States not often in winter. It might be supposed to follow certain tracts of country when communication favored, and at a certain temperature, but as yet no decisive restrictions can be assigned. Many have inferred its identity of distribution with calcareous geological formations, and there seems to be some evidence in favor of this hypothesis, inconsistent as it is with ordinary sanitary causation.

Perhaps enough has been said to show that this scourge scarcely has any distinctive climatological associations, or at least none that may now be defined. If any absolute limitation exists they are not identical with such as we have been considering, or those dependent on temperature and humidity in their malarial signification. Johnston, in the essay several times quoted, goes much farther in enumeration of facts which show no positive relation to climate, though he remarks at the outset that it is "described in Sanscrit works as an endemic climatic disease, limited to the place of its birth, which is the delta of the Ganges and the shores of India. It was first observed as an epidemic in Bengal, in the month of May, 1817; thence it spread first northwest to Mirzapore; next south and southwest, and then continuously in a direction contrary to the monsoons; afterward it extended in all directions, so that within fifteen months it passed through the whole of India to Bombay. It was influenced in its attacks by the state of the weather, the position of a place, and the means of resistance. In summer it was always more severe than in winter, partly from the greater agglomeration of men in the former season." Such is its character here, a plague modified by climatological conditions to a great extent, but never controlled by them so far as to break up its continuity or its propagation over the country.

The following table was prepared by Dr. Engelmann* for the American Medical Association, and the first numbers here are the average for five years of the prevalence of cholera at that city; the dates were 1849, 1850, 1851, 1852 and 1854; and these were the only years of its prevalence since 1841. The second numbers are the average mortality without cholera for 9 years, 1841–1848 :—

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* Sub-Report by Dr. Engelmann prepared for Dr. Reyburn's Report on the Diseases of Missouri and Iowa, published in the Transactions of the American Medical Association, vol. 8, p. 311, &c., 1855.

Monthly Distribution of Mortality from Cholera.

	Jan.	Feb.	Mch.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
St. Louis, av. of five yrs.	11.2	6.	18.2	47.8	183.	626.8	637.4	55.	26.8	19.4	15.8	8.4
Mortality per 1000 without cholera	1.9	1.9	2.0	1.9	2.0	3.0	5.0	4.8	4.0	3.5	2.3	2.4

Comparing the distribution of other diseases with that of cholera it is noticeable that the severest months for fevers are not the greatest for cholera, or that the cholera, as a milder epidemic in its relations to specific malaria, gives way at that season to others. This is more decidedly noticeable at New Orleans, where cholera has several times come in as the preparatory or supplemental epidemic with yellow fever; it was particularly the case in 1853, when the cholera succeeded the great yellow fever epidemic. At New Orleans Dr. Barton's statistics and charts show a steady increase of mortality from April to September, with a rapid decline to the close of the year; August, September, and October giving very much the highest proportions, and representing the high points of the curve. At St. Louis in the absence of cholera the proportions are similar, but with it June and July become the central months.

In the Mortality Statistics of the U. S. Census the following distribution of deaths by cholera for the year ending June 30, 1850, is given for the seasons; it is to be regretted that the numbers were not also given for the months.

	Spring.	Summer.	Autumn.	Winter.	Unknown.
Deaths by cholera, in	1,636	18,243	9,869	1,427	331

The numbers for a single year are of course liable to error as representatives of the law of distribution, but from these citations it is easy to see that the conditions favorable to malarious fevers, or zymotic diseases of this type, are generally, though not always favorable to cholera. A case of direct identity is given by Dr. Hunt in an analysis of the brief prevalence of cholera at Buffalo in 1854 (Trans. Amer. Med. Assoc. 1855), in regard to which he gives the following facts. During its prevalence the temperature was unusually high, with a saturated and oppressive atmosphere; "on the day of greatest mortality" (at a county pauper establishment) "the dew point was 77°.2,"—"the tropical dew-points of 70°, 72°.1, 72°.4, 72°, and finally of 77°.2, on consecutive days, gave it terrible efficiency." "On the 19th of July, the same day when the cholera became so fatal here, it appeared in epidemic form at Suspension Bridge, near Niagara Falls. On the 22d I was requested by the town authorities to visit the place. The mortality of this day, both in its number and in the rapid fatality of the cases attacked, was truly dreadful. During the day there were several showers followed by a hot sun and a still air, and the dew point could not have been less than 80°. The effect of such a saturated atmosphere was peculiarly exhausting and enervating even to the well, great fatigue being induced by very moderate exercise. This condition continued until the 26th. On the 25th I made my third visit. The dew point was 76°.3; new cases were occurring, and a strong tendency to death manifested. About midnight I noticed a marked change in the atmosphere; a strong easterly wind came up, no more attacks occurred, and a manifest tendency to convalescence was exhibited. On the 26th the dew point had dropped to 63°, *and from that hour the epidemic ceased.* I believe I am correct in saying that only one case occurred thereafter."

This is an epitome of the history of the prevalence and severity of cholera *ordinarily*, yet there are instances widely different in character, and in which the zymotic poisons of cold atmospheres appear to be generated. Thus in the later months of 1853 and winter of 1854 it prevailed in almost every emigrant ship approaching our coast. At Glasgow it appeared about the middle of December, 1853, and before the 24th of March following it was fatal in 1306 cases. It became epidemic in London as late as the 10th of October, continuing until December.* In connection with these citations Dr. Smith

* SMITH on the Progress of Cholera, *N. Y. Journal of Medicine*, Nov. 1854.

gives as a conclusion "that its actual progress is almost entirely confined to the hot summer months." The germs of cholera have survived every winter when it commences one of those general progressions so characteristic of this scourge, and it renews itself in the succeeding spring and summer, whether it has wholly ceased in winter or not, near the point where it last prevailed. In this way it has swept the countries of Asia and Europe to come finally to America in two signal instances, that ending in 1832–3, and that ending in 1853–4; in both cases requiring three or four years to make the entire range.

The last period closed with its anomalous prevalence at New Orleans in the winter of 1853–4. Dr. Barton shows that the humidity was less than usual even for December, averaging but 4.167 grains per cubic foot, or 82 per cent. of saturation, the amount of rain during the first half of the month, and while the cholera was severest, being very small, and but 4.56 inches for the whole month. In 1832 and 1834 the severe cholera epidemics at New Orleans were in comparatively cool months; the first in October, and the second closing on the 25th of June.

Dr. Bird* rejects the date usually assigned as that of the origination of Asiatic cholera, 1817, and cites many proofs that it prevailed long before in India, and in London in 1680. He classes it with yellow fever as an epidemic febrile disease, but says, "Cholera has, however, in opposition to the now usual geographical limits of plague and fever, spread itself into all countries however different may be the modes of living and habits of the inhabitants." "There is therefore strong presumptive evidence that, in obedience to the second law mentioned (that of contagious miasms or poisons escaping from the bodies of the infected), it may, and more particularly in cold weather, spread according to the course of contagious disease, and like the typhus of cold countries."

It may be safely said, that if cholera was originally a disease of climatological character and limits, it has now become something more, and, as known to us under the name of Asiatic cholera, has much of the character of a poisonous infection. Climate is, in the temperate latitudes, most signally the incident and modifying agent, and high temperature with great humidity the particularly favorable condition.

Diseases analogous to cholera, though with milder forms and not epidemic, belong to all warm climates and warm seasons, and a close and heated atmosphere develops them invariably if continued for many days.

The opposite class of affections, or those derived from *low temperature* and moisture, are extremely prevalent in the eastern United States. Of this whole class the proportion of deaths from consumption, or *phthisis pulmonalis*, is nearly three-fifths, and as it is difficult to distinguish all of the respiratory class in the statistics, the more reliable are those of consumption only. At Philadelphia for five years, 1850 to 1854, the whole number of deaths from the chief diseases of the respiratory organs was as follows:—

Phthisis pulmonalis	5594, or	120 per thousand of deaths.		
Pneumonia	1923	41	"	"
Croup	1064	22	"	"
Bronchitis	1012	21	"	"

The following table gives first the absolute number of deaths from consumption in the period cited, with the percentage of this number on the entire mortality, and next the number and percentage for all diseases of this class, or of the respiratory organs. A sufficient number of points is given from other sources than the census to support and illustrate those statistics. In some cases the number from pneumonia is large, and the number from diseases of the respiratory organs other than consumption is very variable, sometimes but half the first, and again exceeding it in amount.

* Introductory Address before the London Epidemiological Society, 1856.

Climatological Distribution of Pulmonary Diseases.

	Deaths by Consumption or Phthisis.	Per cent. of entire Mortality.	Deaths by all diseases of Respiratory Organs.	Per ct. of entire Mortality.
London and vicinity (Registry district), last half of 1838(*a*)	—	15.70	—	26.60
England and Wales, last half of 1838	—	19.85	—	27.18
Hastings District, England, mean of 20 years	62	19.23	115	35.06
Maine, year closing July 1, 1850; U. S. Census	1702	22.44	2074	27.35
New Hampshire, Do. Do.	924	21.84	1092	25.81
Vermont, Do. Do.	751	24.09	884	28.24
Massachusetts, Do. Do.	3426	17.65	4418	22.77
Massachusetts, 1853, State Registry	4593	23.48	5783	29.56
Massachusetts, 12⅔ years, Do.(*b*)	35,479	22.44	38,713	27.94
Boston, 15 yrs., 1831–45 (Simonds' Rept.)	—	—	6055	20.97
Connecticut, yr. closing July 1, 1850; U. S. Census	968	16.76	1290	22.31
Rhode Island, Do. Do.	470	20.92	572	25.52
Massachusetts,—Dr. Jarvis, 1841–48 [*1847–8]	—	18.96	22,311*	26.79*
Boston, Dr. Jarvis, 1841–48	—	16.48	—	—
New York (State) 1855, State Census—(Deaths in State, 46,297)	7890	17.04	10,846	23.42
New York (State) 1849–50, U. S. Census	6691	14.67	8800	19.30
New York City, 15 yrs., 1841 to 1855, City Registry	30,167	11.67	—	—
New York " 1855, City Registry	2635	11.43	—	—
Buffalo, 1854, City Records (Imperfect)	266	11.69	386	16.96
Buffalo, 1855, Do.	250	13.51	363	19.62
New Jersey, 1848–50, U. S. Census	915	14.15	1176	18.19
Pennsylvania, Do. Do.	3520	12.33	4821	16.88
Philadelphia (and county), 1849–50, U. S. Census	905	12.96	1186	17.00
Philadelphia, 5 years' mean, 1850–54	1119	12.00	1919	20.63
Philadelphia, 8 years mean, 1809–1816(c)	324	14.94	480	22.11
Philadelphia, 1856, City Record	1501	12.17	2470	20.02
Delaware, 1849–50, U. S. Census	118	9.76	185	15.30
Maryland, Do. Do.	1101	11.44	1679	17.34
Washington City, 4 yrs., City Record, 1850–3; 1854	510	12.42	902	12.97
Virginia, 1849–50, U. S. Census	1616	8.48	3540	18.56
North Carolina, Do. Do.	562	5.53	1688	16.60
South Carolina, Do. Do.	269	3.34	1343	16.69
Charleston, 27 yrs. 1822–48 (Dr. Simonds' Rep.)	—	—	19,919	17.88
Charleston, 18 yrs. 1828–45, Dr. Dawson, City Rep.	1781	12.99	—	—
Charleston, 7 yrs. 1848–54, Dr. Dawson, City Rep.	831	11.66	7125	18.67
Georgia, 1849–50, U. S. Census	279	2.80	1334	13.44
Florida, Do. Do.	43	4.61	108	11.60
Alabama, Do. Do.	362	3.98	1163	12.79
Mississippi, Do. Do.	332	3.81	1067	12.23
Louisiana, Do. Do.	641	5.54	1169	10.03
Texas, Do. Do.	112	3.66	377	12.33
New Orleans, 1853, City Records	755	9.70	1098	14.10
New Orleans, 3 yrs. 1847–49 (Simonds)	—	—	2344	9.81
Michigan, 1849–50, U. S. Census	657	14.55	1084	24.00
Wisconsin, Do. Do.	290	9.99	535	18.43
Ohio, Do. Do.	2558	8.83	3988	13.77
Indiana, Do. Do.	1070	8.42	1824	14.35
Illinois, Do. Do.	866	7.36	1799	15.30
Kentucky, Do. Do.	1288	8.56	2001	13.31
Kentucky, State Registry for 1850	—	9.20	—	17.27
Tennessee, 1849–50, U. S. Census	879	7.40	1493	12.57
Iowa, Do. Do.	159	7.78	376	8.39
Missouri, Do. Do.	645	5.27	1344	10.93
St. Louis, 1851, City Records	204	4.83	376	8.89
Sacramento, California; aggregate of 3 yrs. 1851–3	68	5.44	123	9.83
Havana, Dr. Barton	—	19.50	—	25.07
City of Mexico, 1839	296	5.26	757	13.46

(*a*) From the British Almanac for 1840,—the tables were prepared by Mr. Farr, under direction of the Registrar General.

(*b*) State Registry (Hays' Med. Jour. April, 1855).

(*c*) From a paper on Mortality Statistics in *Trans. Amer. Philosophical Society;* vol. 1, New Series, 1818; by John Vaughan. "Consumption of the Lungs" is very definitely given, apparently, but pneumonia does not appear in the list. *Asthma, Catarrh, Hooping-Cough, Inflammation of the Lungs,* and *Pleurisy,* are the diseases of the respiratory organs named besides consumption. The whole mortality for the eight years is 17,372; of Consumption 2596, Asthma 79, Catarrh 140, Hooping-Cough 310, Inflammation of the Lungs 106, and Pleurisy 611. It is probable that Pneumonia had some share in making up the last number, as at the south it was formerly often called *bilious pleurisy.*

At Charleston, the yellow fever mortality of 1854 is excluded; restoring this the percentage is 10.73; and it is noticeable that the number from consumption is nearly the same with blacks as with whites. Nearly 24 per cent. of the entire mortality is registered as of "*foreigners,*" and probably large numbers of these are from consumption.

The results for the first two British items are from the report of the Registration of Births, Deaths, &c., in the British Almanac for 1840. That at Hastings is for two decennial periods, 1838 to 1847, and 1845 to 1854,—in part duplicating the dates—in the Journal of Public Health for July, 1856. Hastings is a town of the south coast resorted to by consumptive invalids, and has an undue proportion of mortality from that cause for this reason. In the first case, the statistics were corrected and compiled by Mr. Farr, the best English authority, and those for the various cities and subordinate districts of the whole country strikingly agree with the proportions given in the items which have been taken.

The entries for Massachusetts for 1853, and for $12\frac{3}{4}$ years, are from the Twelfth Report of the State Registry of Births, Deaths, &c., prepared by Dr. Shurtleff, and here quoted from the Buffalo Medical Journal for May, 1855.

Much has been said in discredit of the medical statistics of the census of 1850, but the symmetry of the results from this source as a whole, and their correspondence with those from other sources, is sufficient evidence that they are to be relied upon to represent the distribution of the principal causes of mortality. In Massachusetts, when the difference is greatest from the average of nearly 13 years of State registry, Dr. Shurtleff gives but 18.37 per cent. of mortality from consumption for 1849; 21.96 for 1850; 21.73 for 1851; and 23. per cent. for 1852; showing that for the time at which the U. S. Census was taken it is very nearly the same from both sources.

At New York City the U. S. Census gives 11.10 per cent., or somewhat less than the item of the table, which is from the city record.* At Buffalo the city registry for 1854 gives less than that for the whole State, but the succeeding year gives one nearly as great as that of the census.

At St. Louis the city record agrees nearly with that for the State of Missouri. Dr. McPheeters gives in connection with this item (St. Louis Med. Jour., July, 1852) a comparison with that of Philadelphia for the year 1851, which "is 24.08 per cent., showing a mortality almost three times as great from pulmonary diseases in Philadelphia as in St. Louis."

At New Orleans the city record for 1853 is copied from a table prepared by Dr. Macgibbon for Dr. Barton's report on Yellow Fever. The excess it shows over the whole State is readily referred to the character and derivation of its population. In this table, and that at Buffalo for 1853, the mortality from epidemic cholera was thrown out of the total of deaths; the deaths from cholera in New Orleans were 7,849, and at Buffalo 572. In each case the ratio would have been too low if they had been retained. At Havana and Mexico the items are those given by Dr. Barton in the Compendium of the Census.

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* As quoted by Dr. Burwell in a paper in Buff. Med. Jour., August, 1855. The item for Buffalo is from the same source, and also that for Philadelphia.

At Sacramento the statistics were prepared from the city records by Dr. Hatch (N. Y. Jour. of Med., July, 1854), who remarks that they may not be wholly relied upon, yet that it is certain that few of the reported cases of consumption originated there.

The English citations show a mortality from consumption greater than would be inferred from its comparatively equable climate, and the constrained life of multitudes in the manufacturing towns there will doubtless account for some portions of this large number. In the New England States, where the highest proportion appears for this country, a similar cause exists; yet the ratio in Maine and Vermont would show that this cause does not enter very largely into the account, and that it cannot alter the general climatological expression, or affect the distribution of this disease exhibited by the table.

If regarded as a point of *healthiness* alone, it is clear that a still greater proportion than this would be assigned to diseases of the respiratory organs. Very much the larger share of the cases which require medical treatment yield readily to remedies, and the number of deaths is a much smaller fraction of the whole number of cases than in the severe forms of malarial disease. The statistics of cases are rarely accumulated, perhaps never but in hospitals; and in these the milder forms would rarely be received. It may be for this reason that the impression is often derived that climate controls the higher forms only partially, and that the distribution shown by the statistics of mortality illustrates the whole subject. Johnston, indeed, asserts that the statistics of mortality in the army and navy, and of civil population, "warrant the conclusion that consumption is more prevalent in tropical than in temperate countries. Consumption is rare in the Arctic regions; in Siberia, Iceland, the Faroe Islands, the Orkneys, Shetlands, and Hebrides. And in confirmation of the opinion that it decreases with the temperature, Fuch shows, from extensive data, that in northern Europe it is most prevalent at the level of the sea, and that it decreases with increase of elevation above a certain point. At Marseilles, on the seabord, the mortality from this cause is 25 per cent.; at Oldenburg, 80 feet above the sea it is 30 per cent.; at Hamburg, 48 feet above the sea 23 per cent.; while at Eschwege, 496 feet above sea it is only 12, and at Brotterode, 1800 feet, 0.9 per cent. (Physical Atlas.)

The views of this citation are certainly not confirmed in the United States. All forms of disease of the respiratory organs *increase as the temperature decreases* with like conditions of humidity; and increase still more directly with the greater variableness of the climate. Great variations of temperature and humidity in a climate generally cool and damp, afford the conditions most extremely favorable, and this is so well known in the experience of the States north of the 38th parallel as hardly to require statistics to support it. All military and naval records, as well as many from civil sources giving results from warmer climates, fail to distinguish original cases, and embrace very many which have been transferred from high northern latitudes. Large numbers seek milder climates and perish there, whose cases should be set down to the country from which they came.

The authors who have controverted the received opinions regarding the climatological distribution of pulmonary diseases present many eminent names. Dr. Forry says "the annual ratio of pulmonary diseases is lower in the northern than in the southern regions of the United States;" yet his own results greatly modify this statement, and show that at the military posts of Florida and the Gulf there is very little of these; in this great district but 1.7 per thousand of troops suffer from consumption, and but .7 from other forms of pulmonic affection; or but 2.4 per thousand of both. The middle region he shows to have the greatest number. That these cases should be more fatal at the south is reasonable from two causes, the more rapid progress of such a disease, or any other indeed, in a warm climate, and the still more

important fact that patients of this class constantly go southward, almost instinctively, whether in expectation of cure or of mere relief.*

It is undoubtedly true that a mild, equable, elastic climate generates very little of disease of the respiratory organs, and that, after being initiated, many cases may be cured or modified by such climates. If warm and very variable, with much humidity, the requisite conditions are wanting, though some may be favorable. Very variable as the whole area of the United States east of the Rocky mountains is, it will be found that *dry and warm* conditions are required, and the most favorable locality in respect to these two points together is the best. Many localities of the southern interior where sandy surface, terebinthinate vegetation, and non-malarious waters exist, are quite beneficial to invalids, and deserve more attention than they receive as such resorts. In Texas, and on the dry plains, extremely favorable districts exist. Over the whole Interior and Pacific region, these affections will be little known, and in southern California the climate is far superior in this respect to any part of Italy. Equable in temperature, and at the same time extremely elastic and dry, it cannot generate respiratory diseases.

One feature of the census results is the higher proportions of mortality in the southern States than exists in the north from other diseases of the respiratory organs than consumption. This increase is in *pneumonia*, and some doubt rests on the accuracy of the statements of great mortality ascribed to that disease.

	Cons.	Pneu.		Cons.	Pneu.
North Carolina . . .	562	664	Illinois	866	647
South Carolina . . .	269	741	Wisconsin	290	194
Georgia	279	651	Indiana	1070	601
Alabama	362	558	Ohio	2558	895
Mississippi	332	509	Virginia	1616	798
Texas	112	175	Philadelphia, av. 5 ys. .	1119	385
Arkansas	132	187	New York	6691	1461
Louisiana	641	268	N. Y. city 7 mos. . .	1756	992
Tennessee	879	417	Massachusetts . . .	3426	549
Kentucky	1288	429	Mass. 1853	4593	884
Missouri	648	378	Maine	1702	223
Iowa	159	146	Vermont	751	93

These results are too striking and uniform to permit a doubt of their climatological significance, and they strongly confirm the hypothesis of the general relation of pneumonia to malarious districts and autumnal fevers. Louisiana alone, of the States south of Tennessee and Virginia, has as many cases of consumption as of pneumonia, and in the south Atlantic States the disproportion is very great. In all the western States the number for pneumonia is also great, while at the north and east it almost disappears. La Roche has examined the pathology of pneumonia at great length and with great care in view of this particular hypothesis, coming to the conclusion that it is not associated with malarious districts or diseases in any decided manner. He employed no general statistics of distribution however, such as the census has supplied, and if the accuracy of these in detail is questioned, the general result cannot

* Dr. Drake belongs also to the list of those discrediting the received climatological distribution of pulmonary diseases, and particularly consumption. Indeed, he recommended those suffering under or fearing pulmonic affections to *retreat to the colder districts of the country*, citing localities in upper Georgia and near Lake Erie and Lake Superior where favorable conditions exist.

It is apparent that the hasty decline of confirmed cases in hot and humid climates misled Dr. Drake as to causation, and that the bracing climates which are found at the localities named at certain seasons would change to fatal influences at others. *Dry* and equable districts are the great desideratum, though in humid and equable climates it is very far less frequently induced than in those cold and humid.

be, when the States are found to group themselves after strictly climatological relations, as they do also in the case of consumption.* In proof of the influence of cases of extraneous origin the comparison of country districts of Louisiana, the only southern State showing an exception, may be made with New Orleans.

	Consumption.	Pneumonia.
Northern Louisiana	120	174
Southern "	159	71
New Orleans	362	23
New Orleans—1853—	755	184
Northern Illinois	414	235
Middle "	265	236
Southern "	187	176

— In both cases the cities show an excess of deaths by consumption, and the country an excess by pneumonia ; the north of Illinois, which is the least malarious district, and the city of New Orleans both giving a minimum of pneumonia and a maximum consumption. The comparison of city records with those of the census for Philadelphia and New York shows errors in the census, and increases the number of cases of pneumonia but the proportions are not essentially changed.

In California the proportion of cases of this class has been given imperfectly for two points on the authority of Dr. Hatch. Three years at Sacramento, which would represent the average of Upper California quite correctly, give 113 deaths from this class in a total of 1251, or 90.3 per thousand; but of this he remarks, "Certain it is, however, that few of the cases of consumptive diseases hitherto met with in the valley have originated here. In most if not all the instances the disease has been implanted before reaching the country, and the most that can be said is that it has not been benefited by the change." Of admissions to the city hospital, San Francisco, for nearly two years, Aug. 7th 1851, to July 1st 1853, there were 84 in a total of 1,870 belonging to the respiratory class. Of these but 11 were of consumption,—45 per thousand of all, and 5.8 per thousand of consumption. It is believed that the cases of all diseases of this class originating in California will not reach 4 per cent. on the number of deaths, and will thus stand at less than one-third of the number in the eastern States.

The climate of California, by a singular contradiction which probably has its explanation in pathology simply, is reported to develop decided malarious influences over even its most arid surface, and at seasons almost absolutely destitue of atmospheric or surface humidity. Dr. Hatch says that "the prevailing constitution of the atmosphere is malarious," and Dr. Black† insists that "the uncommon prevalence of intermittents in the auriferous region of California" tends to prove the hypothesis attributing malarious diseases to the conjunction of heat, moisture, and vegetable decomposition, almost wholly untenable. He last cites his own experience in the gold region, where he arrived long after the rains had ceased, and remained while there was neither rain, dew, nor fogs; to encounter severe and long continued intermittents with many others who had, like himself, never before suffered from any similar affection. In the day a constant wind from the Pacific prevailed, and at night a wind from barren, snow capped mountains. "The unhealthy season occurs where there is the least possible chance for vegetable decay." But it is reasonable to charge most of these to direct importations from the Isthmus and elsewhere ; and mainly to

* A remark is quoted in Drake's great work from Dr. Roe, of Shawneetown, Illinois, which is strong evidence that pneumonia is in part a malarious disease ; "One worst disease is pneumonia, which will not bear the lancet, and often requires the sulphate of quinia." Vol. i. p. 318.

† On the Ultimate Causes of Malarial diseases, Dr. J. R. Black in N. Y. Journal of Medicine, March, 1854.

dormant disease, such as malaria always implants in the system. The proportion of fevers admitted into the hospital at San Francisco for the period before named was very large,—515 out of a total of 1870. Of fever cases at Sacramento in three years there were 262 of a total of 1261 deaths, without including combinations with other diseases.

The last writer cites the disasters of the British army on the dry uplands of Spain, in the peninsular war, as proof that destructive emanations may be yielded by the earth surface even in a dry climate, producing the effects we charge to malaria,—agues, intermittents, and the most malignant fevers. But if this may be the case in arid countries to some extent it is not so generally, as the experience of explorers and travellers in the interior of this continent shows. All these have been remarkably free from such diseases through the entire history of exploration,* while the explorers of the malarial districts of the Mississippi valley and the eastern States perished in great numbers. Contrasting the two as equally new and unoccupied, the distinction is very great, though the exposure to extreme contrasts of temperature which is peculiar to the arid regions of California does undoubtedly induce remittent fevers. The same author cites a case, indeed, in which simple alternations of temperature of daily recurrence in a cold water bath induced an intermittent paroxysm, —a cold, hot, and sweating stage, though undertaken purely for experiment.

The difficulties presented by this subject of climatological distribution of the diseases having their origin in such conditions are very great, as will be seen by the notices of discrepant views here cited. The two greatest and best defined classes are strenuously disputed, and the preponderance of recent authorities would deny climatological distinctions to consumption and to intermittent fevers in a great degree. Ample statistics are quite necessary to settle these points, and a better criticism of such as are in use. Thus a resort for consumptive invalids like Havana or Malta cannot be made to define its climatological relations by mortuary statistics of imported cases. It must naturally result that the deaths by consumption at these points are largely made up of non-resident cases. In cities to which large migrations tend, or wherever the population is shifting and transient, similar inaccuracies would exist. All vital statistics of army and navy origin are similarly, and even much more, liable to error; as a body of troops may develop cases at one post which had their origin elsewhere, and one climate may fatally advance cases, when originated, which never would have originated at that locality. Such is, pre-eminently, the case in pulmonary complaints if transferred at a certain stage from cold to warm climates. A resident and native population is the only proper basis for the application of such statistics to legitimate deduction, and with very few of such statistics at hand we must be content with approximations.

Geographically the diseases of the respiratory organs of which consumption is the chief have their maximum in New England in the latitude of Boston, and diminish in all directions from this point. As they are controlled by variability, an element of climate not appearing in the averages from which the thermal lines and rain shadings are drawn, they cannot be defined by those illustrations. The diminution is quite as rapid westward as southward, and a large district near the 40th parallel is quite uniform at twelve to fifteen per cent. of deaths from consumption, while Massachusetts

* Dr. Macartney alludes (St. Louis Med. and Surg. Journ., March, 1856), to the existence of intermittents "on the hot, sandy, and dry plains between Missouri and the Rocky mountains, where the water is as pure as ever ran from rocks," &c. "In these elevated situations it is called mountain fever." But he also says it has a typhoid character, with neuralgic symptoms often, and apparent rheumatic attendants. In short it has little of true malarial form.

varies from twenty to twenty-five. At the border of the dry climate of the plains a minimum is attained as low as that occurring in Florida, and one not exceeding five per cent. of the entire mortality. It is still lower in Texas, and the absolute minimum for the continent in temperate latitudes is in southern California. If the entire number of *cases* of all the diseases of this class could be obtained the disproportion would be much greater.

In the United States malarial diseases follow the rain shadings very closely, both as epidemic and endemic. The lower Mississippi and the south Atlantic States near the sea are the maximum districts, and the interior valley and sea coast are followed northward until arrested by low temperature. On the Atlantic coast this occurs while the quantity of rain is still large—in Massachusetts,—and the exception to the relations just indicated first occurs here.

The yellow fever zone is often identified with the sugar zone, or the limit of successful cultivation of sugar cane. We have seen that it is not truly endemic at any point in the United States, or that its local development takes place only in extreme seasons, if at all; and that as an epidemic it may go to Portsmouth, New Hampshire. Though probably not destined to reach such limits again, it may go to New York at frequent intervals, and all Atlantic cities southward must be set down as within the zone of *epidemic* yellow fever.

The limits of the milder malarial forms have before been given for New England and the St. Lawrence valley. Dr. Drake has traced them with great care and accuracy in his work on the Interior Valley at all points west of the Alleghanies, and some of the vertical limits may be noticed here. In southwestern New York, lat. 42°, Dr. Drake assigns the limit in altitude at about 1300 feet above the sea, and as an endemic in natural situations such seems to be the rule. But along all the plateau of great extent at the south of Lake Erie, and stretching through Pennsylvania and southern New York, sources of malaria of artificial origin—reservoirs for canals, and ponds in streams—constantly produce severe intermittents and malignant fevers. Several such cases are cited by Dr. Drake, and the inhabitants are sometimes driven from localities in the highest portion of this plateau, at 1300 to 1500 feet above the sea, by such local, artificially created marshes.

In the country westward there are no altitudes to limit it until reaching Wisconsin, and here the lake border is nearly exempt, with some of the highest parts of the interior, 1000 feet and over above the sea. A line due northwest from Milwaukie would run nearly at its limit across that State, and westward so far as it is known. At the Pacific coast in Oregon it also nearly or quite ceases. Dr. Moses, late of the army, gives the number of cases of intermittents and of all malarious fevers at the military post of Astoria for 16 months, closing with September, 1851, as but nine in a mean strength of 927 men, and in a total of cases from all diseases of 201. There was no death, and the cases are charged by Dr. Moses to exposure and the revival of dormant disease. (Hays' Med. Journ., Jan. 1855.) Of diseases of the respiratory organs there were 27 cases, with no consumption, and no deaths.

The climatal relations of this class of diseases are equally conspicuous when compared among the months, or by mutual comparison of like results in successive years. Thus at New Orleans, St. Louis, and Buffalo, unusually high temperature, and an unusual hygrometric condition concurring, greatly affect them. At St. Louis where malarious forms largely predominate, or those with zymotic diseases not wholly of this class,—particularly cholera,—the average number of deaths monthly for twelve years, 1841 to 1852, shows the following large excess in summer. The second column in each case is the number of deaths per thousand,—at St. Louis for two years, 1852–3, and at New Orleans for over thirty years, 1817 to 1852, the absolute number of deaths in the last case for 1853 only.

	St. Louis.		New Orleans.	
	No. Deaths.	Do. per 1000 of pop.	No. Deaths.	Do. per 1000 of pop.
Jan.	134	2.45	518	3.60
Feb.	125.7	2·45	487	3.01
Mch.	135	2.40	508	3.74
Apl.	151	2.75	510	3.72
May	210	2.65	676	4.52
June	458	4.55	668	5.21
July	593	5.57	2132	5.11
Aug.	355	5.00	6298	8.11
Sep.	245	4.10	1621	8.89
Oct.	214	3.55	700	6.31
Nov.	168	3.00	747	4.07
Dec.	146	2.60	759	3.83

In Massachusetts the curve of differences is a small one through the succession of months, a slight increase appearing in August and September.

The number of deaths at New Orleans was for an extreme year and while the epidemic yellow fever prevailed, yet it does not greatly change the relation of the months which appears in the next column. The maximum falls later in the season than at St. Louis, and the range expressed by the curve of numbers is from temperate to tropical climates, or in other words the latter part of the summer in the lower Mississippi valley is nearly as destructive to health as the tropics, while the winter is not more so than New York or Boston. This peculiarity is characteristic of all parts of the eastern United States.

In illustration of the great variability of the climate in respect to humidity, or the quantity of suspended vapor, the following items are taken from a notice of the peculiarities of the summer of 1853 prepared by the writer.* The temperature of evaporation is that of the wet bulb thermometer exposed to the natural evaporation,—the humidity is the percentage of entire saturation, or the proportion of moisture suspended in comparison with the quantity required to saturate the air at the time. The dates are such as were selected to illustrate the extreme temperatures of the month.

June, 1853. (*All observations at 3 p. m.*)

Burlington, Vt., Prof. Thompson.

	Temp. of air.	Do. of Evaporation.	Humidity. per cent.
14th	91°	76°	47
15	92	75	39
16	82	74	67
17	85	74	58
20	91	78	53
21	82	65	35
22	79	67	50
23	92	76	46
30	89	75	50

Poultney, Iowa, Dr. Odell.

	Temp. of air.	Do. of Evaporation.	Humidity. per cent.
10th	92°	78°	51
11	87	75	55
12	92	77	48
13	96	81	50
14	93	78	44
19	94	81	55
20	97	81	48
21	96	80	47
29	81	72	63
30	84	71	50

St. Martins, Montreal, Dr. Smallwood.

14th	91.3	78.6	53
15	94.3	79.6	50
16	97	79.9	56
17	83	72.8	61
20	86.7	77	65
21	72	61	50
22	61	54.8	66
23	90.6	80	62
30	82	70	55

Washington.

20th	92.5	80.5	57
21	92	81.5	63
22	92.5	79	53
23	92	81	60
24	77	64.5	47
25	75.5	67	62
27	88.5	79	64
28	92.5	77	47
29	94	79.5	51
30	98.5	82.5	49

* N. Y. Journal of Medicine, November, 1853.

BALTIMORE, PROF. STEINER.

	Temp. of air.	Do. of Evaporation.	Humidity. per cent.
13th . . .	82°	70.1	53
14 . . .	87.4	75.2	54
15 . . .	86.9	73	49
16 . . .	87	70.1	40
17 . . .	77.5	70.1	68
20 . . .	95.5	75.3	36
21 . . .	95.7	75.5	36
22 . . .	96.2	78.8	44
29 . . .	88.1	78.9	35
30 . . .	92.3	73.5	38

SAVANNAH, DR. POSEY.

	Temp. of air.	Do. of Evaporation.	Humidity. per cent.
13th . . .	84°	73.9	60
14 . . .	86	68.7	40
15 . . .	85.8	72.6	51
16 . . .	83.8	74.1	61
17 . . .	84	73.5	59
20 . . .	81.3	76.1	77
21 . . .	87.8	78.6	64
22 . . .	92.3	77.9	50
29 . . .	90.8	75.2	46
30 . . .	91.2	78.4	54

AUSTIN, TEXAS, DR. JENNINGS.

10th . . .	96	72	27
11 . . .	98	74	28
12 . . .	83	73	60
13 . . .	84	72	54
14 . . .	90	76	50
15 . . .	86	68	36
16 . . .	70	66	80
17 . . .	90	76	50
18 . . .	94	74	36
19 . . .	97	74	30
20 . .	92	74	39
21 . . .	89	78	59
22 . . .	93	78	49
26 . . .	93	76	43
27 . . .	90	76	50
28 . . .	92	76	45
29 . . .	96	76	37
30 . . .	96	77	39

CLARKSVILLE, TENN., PREST. W. M. STEWART.

4th . . .	86.7	76.4	59
5 . . .	88.1	71.2	41
6 . . .	88.7	72.5	42
11 . . .	84.9	73.4	56
12 . . .	87.4	68	33
13 . . .	87.4	69.8	38
14 . . .	87.4	70.1	39
19 . . .	87.2	68	33
20 . . .	90.1	74.1	44
27 . . .	90.1	72.5	39
28 . . .	91	70.5	32
29 . . .	92.5	74.8	41
30 . . .	92.8	74.5	40

August, 1853. (*All observations at 3 p. m.*)

BLOOMFIELD, N. J., R. L. COOKE.

9th . . .	90	78	56
10 . . .	86.5	72.5	49
11 . . .	86	81	79
12 . . .	95	81	52
13 . . .	98	83	51
14 . . .	91	82.5	69

PHILADELPHIA, PROF. KIRKPATRICK.

10th . . .	91	77	51
11 . . .	93	80	55
12 . . .	93.5	81	68
13 . . .	92	81	61
14 . . .	92.5	81	61
15 . . .	86	78	68

AUSTIN, TEXAS, DR. JENNINGS.

6th . . .	96	78	42
7 . . .	96	77	40
8 . . .	94	75	38
9 . . .	88	76	55
10 . . .	86	76	61
11 . . .	85	76	64
12 . . .	76	76	100

JACKSONVILLE, FLA., DR. BALDWIN.

10th . . .	87	80	72
11 . . .	86	79	72
12 . . .	87	80	72
13 . . .	87.5	80	71
14 . . .	89	83	76
15 . . .	87	79	69

These numbers illustrate the range of the hygrometric condition in the United States generally, as well as the particular condition considered. The month of June was very warm for the dates cited, and it very well represents the extremely warm and dry periods which frequently occur in our summer. At all of the very high temperatures the percentage of saturation is low, and frequently at 30 to 40 per cent. The wet thermometer rises above 80° in but two cases, at Washington and in Iowa, showing the central districts to be dry at the time of the great increase of temperature.

But in August the temperatures at Bloomfield, near New York, and at Philadelphia, are not only very high for the dry thermometer, but still higher in proportion for the wet thermometer, some observations giving 84° for the temperature of evaporation at

New York City. No others are so high anywhere, and the single observation of 83° at Jacksonville, Fla., was at an air temperature of 89°, or 9° less than those observed in New York. In Texas the low degree of humidity is clearly shown, no observation of the wet thermometer going above 78°, though the dry air reached 98°.

The climate of the Gulf coast, comprising a large area in the southern States, is very humid, or contains a large quantity of vapor, though not in sensible form as clouds or fog. Dr. Barton has accurately observed it at New Orleans for many years, and the following results for 1853 will show nearly the general average there. The humidity is the percentage in each case; that at New Orleans is for 1853, at St. Louis for 1855, and for Greenwich for 5 years, 1849 to 1853.

	New Orleans, Humidity.	New Orleans. Weight of vapor, grs. pr. cub. foot.	St. Louis.	Greenwich.
Jan.	88	3.85	68	85
Feb.	84	4.58	67	85
Mch.	83	5.38	61	80
Apl.	83	6 80	46	80
May	84	7.60	66	75
June	81	9.14	69	73
July	82	8.80	70	77
Aug.	87	9.74	78	77
Sept.	85	8.57	80	74
Oct.	80	6.05	63	83
Nov.	84	6.06	71	86
Dec.	82	4.01	68	84
Year	86	6.72	67	80

This shows a high measure of humidity for the whole year at New Orleans, and an excess of vapor in the air in the warmer months proportioned to the excess of mortality for those months. At St. Louis the humidity is greatest in summer, the months of greatest mortality, while at London the percentage is much less at the same part of the year.

XVII. PERMANENCE OF THE PRINCIPAL CONDITIONS OF CLIMATE.

THE great degree of inconstancy and variability belonging to all the elements of climate during any definite succession of years has attached ideas of change to the whole subject which it is difficult to remove. The contrast of places in like latitudes, and the impossibility of applying any formula derived from the intensity of the sun's heat, have directly favored the idea of irregular changes, at the same time that they have prevented the mathematical demonstration which belongs to all quantities in physics. It is believed that the absolute fixedness of the measure of heat derived from the sun is capable of a demonstration as conclusive as that of any astronomical problem, and that whatever may be supposed of the interior heat of the earth in the early geological ages, or now, there has not been, for a period so great as to render the application of the remark conclusive for the full history of man's occupation, any climatological source of heat other than the sun. If the sun's heat is a constant quantity therefore, all the changes we observe are periodic as belonging to the day and year, and non-periodic in all other cases—the averages always returning to a line of the most absolute permanence. And as all other conditions than temperature depend upon that, when not strictly local, the quantities of rain, and of atmospheric humidity are also permanent, with all other conditions of a general character.

The demonstration of this constancy of the sun's heat cannot be undertaken here, and though it has not yet been made in any direct manner, the possibility of such demonstration will be admitted by all who would follow that tone of proof. For this place the results of observation and historical citation are more appropriate, and the space available for the purpose will be given up to them.

Laplace has shown that the mean temperature of the mass of the earth cannot have changed in any appreciable measure within the entire period embraced by astronomical calculation, and that none can occur while the planetary movements remain what they now are. Climate belongs to the physics of the earth's mass as directly as do the tides, with the exception of the exterior agency of the sun's heat,

and if we determine that to be constant, all that remains may be treated according to the rules applicable in every other department of physics. The surface of the earth and its geological structure have at some remote interval undergone great changes, but there are none now in progress which are sufficiently important to influence the climate in any degree. Whether the relations of mass were always the same as now between the land and sea we are unable to say; changes of these would greatly affect the distribution of heat, whether the measure for the whole earth underwent any change or not. But it is certain that no changes of subsidence, elevation, or continental outlines, have occurred within any period which might give reason to believe that such changes belonged to the present order of things;—it is certain that none such are now in progress.

The great differences of surface character which belong to the deserts, woodlands, and other more striking features, are believed to have their *origin* in climate, and not to be agents of causation themselves.

The more common ideas regarding local changes base them on circumstances affecting the surface within our control, such as the removal of forests, draining, and cultivation; and the reaction of these superficial changes on the heat and moisture of the air is supposed to effect the modification. It necessarily follows that the surface controls the character of the atmosphere fully as much as the atmosphere controls the surface or more, otherwise the greater agency would gain until it produced entire conformity,—or the tendency to return to the original condition would be too strong to permit the artificial change to attain any considerable measure. If an extensive forest were removed, the agencies which placed it there originally would constantly tend to its reproduction, and would at some time reproduce its equivalent; never being annihilated unless they were themselves inferior agencies. It is sometimes thought that in Syria the removal of forests has rendered the soil barren and the climate too arid for cultivation, and this would be reasonable if we suppose that any artificial agencies may permanently modify our own climate.

A moment's reference to this general point of causation will, it is believed, render it clear that the climate originates the capacity for cultivation with all the incidents of that capacity, and that if the most extreme desert surface of the earth were brought under the conditions prevailing in the British Islands, for instance, those conditions would clothe it with vegetation and cultivable soil, and equalize its seasons in the end. Looking at the desert belts of both hemispheres it is clear that they are due to geographical position, and that they are not self-creating; they are in such latitudes, and so placed in relation

to the continents that the precipitation of moisture in rain does not reach them, and cannot reach them under the existing system of evaporation and precipitation. Even the sand is but an incident of the previous dryness; in the sand deserts of California the substratum is a tenacious clay, and there is fully the usual proportion of clay and tenacious earths over all the American desert region. In the Mississippi valley, and on the Atlantic slope, there is sand enough to drive over the whole country as freely as sand now drives in the Asiatic deserts of the same latitude. The African Desert is known only at the borders, where the slow encroachments of untold centuries have heaped the sands beyond any natural proportion, and that area may have been more completely covered with sands also in its original state. The arid belts are in the same continental position in each case, beginning at the ocean level and shore on the west of the tropic borders of both continents, and extending northeastward inland over areas proportioned to the dimensions of the general continental mass.

For the whole of the vast historic period there have been the same deserts in Africa and Asia, the same absence of water in the rocks and soil, and the same capacity for excavation and occupation of their quarries existed in the most ancient time as now. The primary need of water has not changed since the earliest tomb-building of Persia and Egypt, so far as we may judge by these evidences themselves, and if we find the greater distinctions to be so evidently permanent, we may reasonably assume that minor ones are so, until the fact of change is shown.

If this exterior view is correct, the absence of forests and of vegetation is the consequence of climatological defect, mainly, if not wholly. The most unmixed sands of well watered regions are rarely left without a forest covering, or without at last becoming cultivable and productive. Though they react locally to some extent, particularly where the sun is felt with force, and produce some rarefaction of the surface air, increasing the heat of the surface and diminishing the surface humidity, there is still but the most merely superficial change known to be due to a surface of sand. We find such surfaces scattered over every part of the humid area of the United States with no interruption of the general condition, and no diminution of the quantity of rain. These sand belts are very extensive along the whole coast of the Gulf of Mexico and the Atlantic, and if we could suppose surface to control climate, such instances should be found here.

Immense areas here are natural plains also, destitute of trees, and with the most exposed surface. With the exception of some local severity of winds, the interspersed areas of prairie in the States east of the Mississippi,—in some of which five hundred square miles of such area lie in one body,—differ in no respect from the woodland belts in regard to the quantity of rain. Near the lakes, indeed, striking proofs of the superiority of general causes are shown in the very rapid decrease in the quantity of rain along a line from central Illinois to the woodland areas of northern Michigan, and the islands of the lakes. On the great central plain of Illinois the quantity of rain is fully one-half greater than at Fort Gratiot on Lake Huron, or at Mackinac and the

outlet of Lake Superior. If exterior causes are thus superior agents in fixing these conditions, the permanence of these conditions depends on the first, and not upon local influences.

The leading element of climate is the measure of heat, and this is also directly related to the mass and density of the earth. Laplace has shown that these cannot have changed for the vast period over which astronomical calculation can reach, since a change of absolute or relative motion would have been certain to attend it. Astronomical permanence implies an absolute fixedness of the quantity of heat for the mass of the earth, and if a change of this is in progress its degree is too small to be measurable at the surface in any period within our reach. The existing "poles of cold," and belts of varying temperature, are equally incapable of displacement without causing derangement of motion, and having accepted the proof of fixed planetary motion as sufficient and conclusive, the most positive proof of change of temperature is necessary before we are at liberty to speculate upon such inconstancy.

The variable positions with respect to the parallels which we now find to belong to the isothermal lines have unsettled the earlier theories of distribution of heat in latitude, and shown that one class of superficial agencies has more influence than was at first supposed. But these are fixed even in their irregularity of place, and the Gulf stream, the belt of westerly winds, and the monsoons, are but representatives of a large class of permanent influences, of greater or less degree, which control this feature of the distribution of heat. Each of the localities so influenced must be observed, and its measure determined from actual experiment. These variable results more than anything else give the impression of inconstancy, or of determinate change of climate, and they greatly accumulate labor in the business of coming to settled conclusions from even the amplest collection of facts.

In illustration of the question of permanence a large mass of historical and statistical matter might be given, and the selection for the space here available is somewhat difficult. Real history would be more valuable than anything else if it could be relied on, but there is great looseness with much exaggeration in everything dating back beyond the use of instruments. In classic history, particularly, the unknown countries at the borders of Greek and Roman dominion were dressed in fanciful exaggeration by all the writers of the time, and it is impossible to say whether the allusions are of value or not. They have been in turn quoted by Schouw, Arago, Humboldt, Noah Webster, and others on the side of those who discredit their evidence of change of climate, and by Dove, Brewster, the Duke of Ragusa, Dr. Williams of Cambridge, &c., in proof that more or less of change of climate has taken place.

In citing historical notices it may be well first to refer to the frequently mentioned visit of the Northmen to America, and to the proof it has been held to afford that the New England or Newfoundland coast was once a "vine land"—having grown colder along its whole extent, and including Greenland, until the last has been depopulated of its flourishing colony of the 11th century, and the vine has ceased to grow north of New York. The best references to this visit of the Northmen are reproduced in Wheaton's history,* and from this it appears that successive landings along the coast under Lief, son of Eric the Red, in 1002, brought the party to "a woody country, abounding with delicious fruits and berries," where the days and nights were nearly equal for much of the year, though when shortest the sun rose at 7½ and set at 4½ o'clock. This would be nearly at the latitude of Boston. Of this party one Tyrker, a German, who had known vines in Europe, though they were unknown to the Northmen, wandered into the woods and was lost, but he ultimately found his way back bearing some specimens of wild grapes and vines which he had found. Lief went to the locality, and finding others, gave the country the name of *Vinland*. The ship returned to

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* Henry Wheaton's History of the Northmen, Philadelphia, 1831.

Greenland the next summer, and in the next succeeding years Thorwald and Thorfin brought out a number of persons, but subsequently communication ceased until 1509. These circumstances are very clear proof that but one locality of vines was found, and that the rarity of the growth, and the importance attached to it by the German originated the term,—not any especial adaptation of climate beyond the present capacity of being favorable spots at that latitude to produce wild vines. The structure on which so much speculation in regard to causes of the change of climate has been based wholly disappears on examination, and on the contrary, we learn that the Northmen found the New England coast eight hundred and sixty years ago quite precisely the same in climate as now—wild vines growing in a very few of the most favored spots, and only in these.

The condition of Iceland and Greenland has often been cited in proof of the view that the climates of the north Atlantic coasts have grown colder within the historic period. The histories and records by which the point may be examined are difficult of access, but they are still ample to disprove the whole hypothesis. Olafsen, a Swedish writer on whom Wheaton and Leslie rely, has written more fully than any other perhaps upon all the points presented by the question, involving, as they do, the entire interests of the Icelandic population, agriculture and navigation most of all. Sir John Leslie has also examined the theory very thoroughly, and his result decides it to be wholly unfounded. The original terms were *Snoiland*, and *Iceland*, as applied by the Northmen discoverers. They found snow and ice, and seasons of great severity ; in 1233, 1261, 1306, and 1348 ice lay in masses on the north coast of Iceland through the whole summer. In the last named year and in 1615 the ice surrounded the island during the summer, and in 1639 and 1695 it covered much of the eastern coast. In 1717, 1742, 1784, and 1792 the seasons were remarkably severe, yet none so cold as that of 1348.

The earliest discovered forests were mere shrubs, unfit for building houses or vessels, and drift wood was then, as now, employed mainly for these purposes. It is noted as a great feat of skill that two men among the earlier colonists were able to make a boat from timber of the native growth sufficiently large to carry them back to Norway. There can scarcely be a more decisive proof that no decided change of climate has occurred than this derived from the character of the forests growth, since a climate very little milder than that now known in Iceland permits heavy forests, as is seen at Sitka and on the Yukon in northwestern America.

The attempts of Frederick V. in the middle of the last century to revive agriculture in Iceland are said by Olafsen to have failed only because they were not prosecuted with sufficient vigor and perseverance. The grain ripened as well as it does in the Faroe Islands, and there is no proof that grain ever ripened fully in Iceland. This soft state and incomplete ripening is common in the north and west of the British Islands, as in all cool and humid climates. The mean temperature for the summer at Reikiavik is but 52°.9, which is at the limit of barley cultivation. At Lead Hills, Scotland, wheat ceases at a summer mean temperature of 55° ; at the Faroe Islands the mean is 54°.5, and barley grows, but wheat does not, yet barley ceases to grow on these islands at 400 to 450 feet above the sea. These clear and narrow limits show that the present condition of Iceland is fully equal to its geographical position relative to the west of Europe and the British Islands ; and that if we are to suppose that formerly this island and Greenland had a much higher temperature we must suppose all the west of Europe to have shared in the change. In Scotland cultivation and skill have extended the growth of wheat much farther north than it existed in early times ; and it has been carried several hundred feet higher also. Thorough draining has rendered the growth of wheat successful north of Aberdeen, and at many points of uplands and moors where three centuries since it was unknown. With the decline of this skill and care it would again recede, and a condition like that characterizing the present agriculture of Iceland would ensue.

The case of Greenland is quite as clear. In the day of energetic colonization by the Northmen settlements were formed there, which were stimulated by the usual exaggerations of interested explorers. The fisheries, and the profuse arctic life of the west of Greenland sustained these establishments, and encouraged them as long as active communication was kept up with Norway and Denmark. In this way the two historic *Bygds* were built up, one of which, the *Wester Bygd*, was easily broken up by the Esquimaux invaders, said to have come on the west of Greenland then for the first time, on the discontinuance of communication with the mother country. The second, *Auster Bygd*, for a long time held out, but the absurd misgovernment by which a monopoly of communication was attempted on the part of the ruling king ultimately broke up the whole colony. Colonies stronger than these have been frequently broken up by such misgovernment, and no proof of essential change in any physical condition of any part of Greenland exists by which this effect can be deduced as a consequence. It is decided by the fullest research that neither of these *bygds* or settlements was on the eastern coast. That coast was then, as now, formidable from its immense and unbroken ice barrier, and so long as the Gulf Stream exists, the answering return current which brings this mass of ice on the east of Greenland must exist. The one is a necessary attendant of the other, and the agent of unusual heat in the higher seas in the line of that stream becomes an agent of refrigeration where the return current exists. The position of the large land mass constituting Greenland assists this refrigeration at the east, and it could never have been habitable unless the whole Arctic climate should also be greatly modified.

The colonists of Greenland continued to rely upon their native lands of Europe for bread during all their occupation of the country, and when this resource failed them they were broken up. The activity and enterprise which prevailed during the four hundred years of the existence of the republican government of Iceland would again plant colonies as flourishing as those of the eleventh and twelfth centuries. The present actual occupation by traders, Esquimaux, whalers, and explorers, equals, if not indeed largely exceeds the celebrated occupation by the Northmen.

It thus appears that the entire structure of belief that the climate of those northern regions has changed has been based on a few inferences, that drawn from the term *Vinland* being one, and the abandonment of the Northmen's colonies in Greenland perhaps being the principal. But this theatre of the Northmen's activity has now far the mildest climate of the earth for its latitude, and it would imply a far greater measure of heat for the earth in high latitudes as a whole than now exists to suppose these extreme points to have been much warmer at a period so recent as the tenth century. History is decisive that Europe in the middle latitudes was no warmer, and the common historical references, indeed, cite much colder winters in Germany and about the Black Sea. The two asserted changes are wholly irreconcilable, and in all probability neither has any basis.

The references to permanent changes of climate are so numerous that a condensed abstract of the views of several authors may be the best mode of introducing them here. In the United States the idea that a change was in progress was entertained at an early day. In the first volume of the American Philosophical Transactions (p. 336, paper read Aug. 17th, 1770) Hugh Williamson, M. D. submits a paper entitled "*An attempt to account for the change of climate which has been observed in the Middle Colonies of North America.*" His points are, that the winters are not so intensely cold within the last forty or fifty years, nor the summers so intensely hot as formerly, results which he attributed to cultivation. Several minor papers and references to the same purpose appear in various publications of the time.

Samuel Williams, LL. D., Professor at Harvard University for many years, and author of a series of thermometric observations from 1780 to 1788, in a History of Vermont written subsequently, asserts that "the winter is less severe, cold weather

does not come on so soon" as formerly; and he computes the change at Boston at 10° or 12° from 1630 to 1788. He also recites the historical notices for Europe, and concludes that in Italy the change to warmer temperatures is not less than 17° in 18 centuries, and in Germany 16°. (2d Edition 1809.)

Humboldt makes the following references to the United States in his *Views of Nature*, "The statements so frequently advanced, though unsupported by observations, that since the first European settlements in New England, Pennsylvania, and Virginia, the destruction of many forests on both sides of the Alleghanies has rendered the climate more equable, making the winters milder and the summers cooler,—are now generally discredited. No series of temperature observations worthy of confidence extends further back in the United States than 78 years. We find from the Philadelphia observations that from 1771 to 1814 the mean annual heat has hardly risen 2°.7, an increase that may be fairly credited to the extension of the town. This increase may also be due to accident," &c. There is no evidence of any appreciable change afforded by the American series, either in the direction here indicated, or in others which have been inferred. At Salem and Cambridge, Mass., as in some of the recent series at Philadelphia, the averages for recent periods are less than in the earlier ones, but the reason for this lies in the modes of observation, or in the rating of instruments, where difference of local position does not account for it.

Jefferson makes several approving references to the opinion that the climate of the United States was modified by cultivation as early as 1780, and supposes that further changes of this sort are to ensue. In Elliott's Sketches of the District of Columbia it is asserted that snow and ice were formerly more frequent and severe at Washington; and Rush and Volney make many similar statements. Kalm (Pinkerton's Travels, xiii. p. 680,) appends citations to show that the climate had grown milder at Quebec previous to 1750,—corn ripening where it formerly failed. Dr. Holyoke also inclined to the opinion that the climate had softened during his long period of observation, or rather that it was then milder than in the early history of New England. Following these, a number of European writers—Buffon, Gibbon, Hume and others—copied the opinions so loosely asserted by the writers named above.

In opposition to these views Dr. Noah Webster has made the most thorough review of the question both for America and Europe, with the conclusion that "the hypothesis of a moderation of climate appears to be unsupported" for either continent, and in the paper from which the remark is here taken, Dr. Forry adds to liberal citations from Dr. Webster's essay, a strong array of independent proof that there has been no change in the climate of Europe within the historic period, and none in America since its settlement.*

For Europe and Asia the authors on both sides are too numerous for a full review. M. Dureau de la Malle undertook an elaborate investigation of the climate of ancient and modern Italy, concluding it with the most decided expression of his opinion that there had been no sensible change in climate, and none in the local geography of plants or in any other of its incidents.

M. Schouw, Professor of Botany at Copenhagen, wrote a treatise "*On the supposed changes in the Meteorological Constitution of different parts of the Earth during the Historic Period*," (first given to the Royal Society of Copenhagen, and in part printed in the Edinburgh Journal of Science for 1827–1828)—a large work which goes into the Antediluvian period. He refers to the errors of memory in such cases—cites the Date-palm and vine of Palestine; the date was always restricted there, it requires a

* American Journal of Science, 1844. Dr. Webster's paper "*On the supposed change in the Temperature of Winter*" was given to the Connecticut Academy of Arts and Sciences, 1799 and 1806; and reprinted with a collection of Dr. Webster's papers in 1843.

mean temperature of 21°, (Reaumur, 79° Fahr.) and Palestine has this temperature now. The ancient harvest time was the middle of April to the end of May—it is the same now. Barley is yellow with ripeness at the middle of April, and wheat is ripe at Acre by the 13th of May.—The old feast of the Syrian wine harvest in October is the same now.

Theophrastus gives the range of plants in Egypt, and their range is still the same. The lily, *nelumbium speciosum*, a historic plant mentioned by Pliny and Strabo, is not now in Egypt, but it exists in colder climates, at the mouth of the Volga in Europe and Japan in Asia, proving that chance, and not change of climate, has driven it from Egypt.

The harvest at Rome was formerly near May 18th (Columella) ; it is now near the 14th. Schouw also examines the asserted changes near the Black Sea, and shows the contradictions and absurdities of the early writers. The vine now grows in the Crimea if protected in winter, and even olives in the valleys opening to the south.

Arago published a memoir in the *Annuaire* for 1834 to show that since the time of Moses the temperature of Palestine has not changed. In the same memoir the permanence of the vines in the valleys of the Rhine and the north of France is conclusively shown. A change of temperature so great as two or three degrees would destroy the vines wholly if to the colder side, and if the change were to the warm side, vine cultivation would be very largely extended over uplands where it has yet never been grown.

The growth of vines and the business of wine making are so generally held to be an accurate measure of the European climate, that any change in capacity in this respect would be regarded as positive proof of change. In the frequent references to such facts, however, the looseness of historical statement has given ground for the most opposite opinions, but the following review of the facts and condition in England is evidently complete and decisive. In France and Germany the permanence of position for the vine is generally conceded, but England and the countries bordering the Black Sea are much disputed, some claiming great change to warmer seasons and some to colder ones, and all citing vines, wine growing, and the absurd tales of the ancient freezing of wines, as proof in opposite cases. An early number of the Philosophical Magazine (No. 108) contains the essay here quoted.

"Writers generally speak of Britain as in past ages a vine growing country, but there is no sufficient testimony in favor of this position, and some directly against it. The first positive authority in favor is Bede, who says, 'vineas etiam quibusdam in locis germinaus.' (*Hist. Ecclesiast.* i. 1.) It is here important to observe the 'quibusdam in locis.'

"The next is Domesday Book, which mentions vineyards in several places. At Rayleigh, in Essex, we are told 'there is one park and six arpennés of vineyards, which, if it takes well, yields 20 modii of wine.' But the indication of a few here and there precludes the idea of extensive cultivation.

"At a subsequent period many authorities prove the existence of vineyards in particular spots, and generally in connection with cathedrals and religious houses. The success of these may be judged from that at Ely, where the sale of *verjuice* forms a considerable share of the profits.* Only one passage has been quoted which would at all seem to imply an extensive cultivation of the vine in ancient times, and even in that (from William of Malmesbury, boasting of the superiority of the vineyards of Gloucestershire) the terms are too vague to allow of any positive conclusion.

"This belief then, has no other authority than the existence of the grape in a few localities. Plot (of Camden, Staffordshire) tells us that in 1685 Dr. Bathurst, Presi-

* In the 12th Edward 11, the wine from the vineyards at Ely sold for £1 12s., and the *verjuice* for £1 7s. In 9th Edward IV. no wine was made, only verjuice.

dent of Trinity College, Oxford, made as good claret 'in a very mean year for that purpose,' as one would wish to drink; and Pepys says that in the reign of Charles II. very good wine was made at Walthamston. Miller gives a list of places at which wine was made in the last century, among which are Rotherhithe, Brompton, Kensington, Hammersmith, Waltham Green (for 30 years), Arundel, and Paris Hill near Cobham. In these cases it was equal to French wine of the second class ; at Paris Hill equal to champagne, and sold for 50 guineas a hogshead. Against the growth of wine on a large scale in ancient times there is evidence from Plutarch, who, according to Miller, speaks of the people of England as not drinking wine. Lord Bacon also says that grapes require a south wall to ripen."

In the same connection it is said that "there are, and always have been, vines in Fayoum, one of the hottest portions of Egypt, where they were cultivated by the Copts. 'At Esné, in the highest parts of Upper Egypt, 12 leagues south of Thebes, a vineyard of the extent of several *feddams* exists. Jussuf Kiacheff, a former soldier, founded this vineyard and made wine.' (Duke of Ragusa, in Jameson's Journal, No. 40.)"

The statistical data for examining the question of permanence of climate are not sufficient to decide it positively of themselves, though they may be largely accumulated in various forms. The period over which temperature averages may be compared is about one hundred and thirty years, or nearly the entire series since 1720. Of the more accurate periods, sixty or seventy years embrace the full limit of those which are observed by instruments which have been verified. There are some extended periods for which the quantity of rain has been measured in Europe, though we have not the detail of them, nor the requisite notes explaining the circumstances. There is still another observation to which numerical calculation of averages can be applied, which is the date of the opening and closing of northern rivers and lakes. One of these reaches much farther back, the date of breaking of the ice in the Duna or Dwina river, at Riga, on the Baltic, and the period begins with the year 1530, though there are interruptions at the close of the 17th century and the beginning of the 18th. This series is so full of interest that it may be given for periods of half a century, and again for decades of years. The full table is in Kupffer's *Annales de Observatoire Physique Central de Russie* for 1850.

Dates of breaking of ice in the Dwina River, 1530 *to* 1852.

For 52 years	1530 to 1623	mean date, March	28.2	(Old style)
" 52 "	1626 " 1750	" "	24.4	"
" 52 "	1751 " 1802	" "	25.3	"
" 50 "	1803 " 1852	" "	27.5	"
Whole period of 206 years		" "	26.3	"

At St. Petersburg the 9th of April (old style) is the mean of observations since 1718 ; which gives a difference of 14 days between the breaking up the rivers Dwina and Neva. The mean dates of the first period in decades is as follows :—

1540, '43, '52, '56 to '58 and '62 to '65	March	29.7	1753 to 1762	March,	23.2
1566 to '68, '71, '72, and '76 to 80	"	24.8	1763 to 1772	"	29.1
1581 to 1590	"	28.0	1773 to 1782	"	23.9
1591 to 1598, 1601, '2	"	31.1	1783 to 1792 (Apl. 1.2)	"	32.2
1609, '12, and 1615 to '23	"	27.0	1793 to 1802	"	20.4
1651 to '53, '59, '62, '67, and 1709 to 1712	"	17.0	1803 to 1812 (Apl. 4.4)	"	35.4
1713 to 1722	"	26.8	1813 to 1822	"	23.9
1723 to 1732	"	26.7	1823 to 1832	"	25.4
1733 to 1742	"	20.3	1833 to 1842	"	23.6
1743 to 1752	"	24.9	1843 to 1852	"	28.8
Of the hundred years here included	"	25.63	Of the last century	"	26.6

Mean date for 200 years, March 26.11 ;—of the first 70 years observed, 1540 to 1722, March 23.5 ; of the last 70 years, 1783 to 1852, March 24.2.

The first and the last decades, separated by a period of 300 years, differ but one day in the mean date of this phenomenon ;—the first two and the last two decades have the same measure of difference ; and the first and last seventy years differ but seven-tenths of a day, both being earlier than the mean of the whole period. The thermal condition is shown to be so far permanent that three centuries give no appreciable measure of curvature or divergence in any direction. The popular impression that the climate of the Baltic districts passes through great changes in the course of a few centuries, and that it now differs widely from its condition in the earlier historic period is thus shown to have no foundation. This hypothesis has been made the basis of a sort of scientific speculation also, and fanciful theories of the recurrence of warm and cold periods have been put forth.

The date of the closing and opening of the Hudson River at Albany has been given with accuracy for many years in the reports of the Board of Regents of the New York University, and from a recent report the computation has been made for a period of 63 years, 1790 to 1852, to afford some parallel to the Russian observations. The dates of closing of the river for decades of years are as follows :

1790 to 1799	Dec.	16.9	1830 to 1839	Dec.	10.6
1800 " 1809	"	31.6	1840 " 1849	"	13.6
1810 " 1819	"	13.9	1843 " 1852	"	16.7
1820 " 1829	"	17.4	1790 " 1852	"	17.3

From this comparison it appears that the mean dates for the first and the last decades are the same, and both differ but a very little from the mean for the whole period. There are two extreme periods,—a warm one from 1800 to 1809, and a cold one from 1830 to 1839. The change which might with some reason be inferred if the dates began and ended with these decades, becomes improbable in view of the whole, and this permanence of a single phenomenon for 63 years at least proves that there has been no change of importance in the general measure of heat for the climate.

The longer periods of observation of mean temperature might be analyzed at great extent, since there are several of these of sufficient value to repay it. At London the Royal Society's observations are almost complete from 1771; those at Zwanenberg, Holland, from 1743 to 1835 ; and at Berlin from 1720, with some interruptions, to the present time. The first series has been very carefully corrected and analyzed by Glaisher, and a summary of the results may be given here. Giving the comparison of this period of 79 years in decades first, the differences are as follows—the mean of each ten years differing from the mean of the entire period by the measures here given.

		°			°
1771 to 1779	(9 yrs.)	—0.1	1810 to 1819	10 yrs.	—0.2
1780 to 1789	(10 yrs.)	—1.1	1820 to 1829	"	+0.5
1790 to 1799	"	—0.5	1830 to 1839	"	+0.3
1800 to 1809	"	+0.3	1840 to 1849	"	+1.0

The table of departures from the mean of this series, as constructed by Glaisher, affords the opportunity to verify this equality in another way,—taking it in two equal periods the *number* of departures above and below the mean is alike for each branch, whether these differences are taken for the months or for the years. If any absolute divergence existed it would appear in some of these numerical forms of comparison. Some extreme non-periodic variations occur in the series, the cold years 1812 and 1816 being the principal, but there is no uniformity of variation in any part of it, and no periodical recurrence of like differences. Of other points Glaisher speaks as follows. "These numbers do not at all confirm the idea that a hot summer is succeeded or followed by a cold winter, or *vice versa ;* on the contrary it would seem that any hot or cold period has been mostly accompanied by weather of the same character. The cold year, 1771, was followed by two cold years. The hot year of 1779 was preceded by one warm year, and followed by two others. In 1780 the extreme cold of January

was more than counterbalanced by the extreme heat of March. The cold year of 1782 was followed by a long series of cold years. The very cold year 1799 was followed by a cold autumn and winter. The warm year 1806 was preceded by a warm winter. The very cold year 1814 (the last very cold year) was preceded by a cold summer, autumn, and winter. The hot year 1818 was preceded by a moderate winter and followed by a warm one; the hot year 1822 was preceded by a warm winter and followed by a moderately cold one; the hot year 1834 followed a very mild winter, and was followed by another. The hot years 1846 and 1848 were both preceded and followed by warm periods. In the whole series at London, 1771, '82, '84, '86, '99, and 1814 were below 46°; and 1779, 1818, '22, '34, and '46 were above 50°.5. 1784, the coldest, was at 45°.1; 1846, the warmest, 51°.3; range 6°.2. The mean of the whole series 48°.3."

Of the series at London it should also be said that the years observed since 1849 are decidedly colder than that period, and that these recent years would give a depression below the mean of at least half a degree.

A series of temperature observations at Zwanenberg, Holland, is given by Dove in the *Berlin Transactions*, which is continuous from 1743 to 1835, or for 93 years. The several decades of this period show the following small departures from the mean of the whole. It is noticeable that the two extreme periods, of 23 and 20 years, are very nearly at the same position.

		°			°
1743 to 1755	13 yrs.	—0.56	1806 to 1815	10 yrs.	—0.32
1756 " 1765	10 "	+0.46	1816 " 1825	10 "	—0.17
1766 " 1775	10 "	+0.95	1826 " 1835	10 "	+0.01
1776 " 1785	10 "	+0.52	1743 " 1765	23 "	—0.12
1786 " 1795	10 "	—0.60	1766 " 1815	50 "	+0.20
1796 " 1805	10 "	—0.36	1816 " 1835	20 "	—0.08

The discussion of this and the previous period in divisions for five years each has been made for this place, but it is nothing more than a refinement upon the result here given. It is impossible to discover any periodicity in the departures, or any fact differing from those exhibited in the series given in detail in the tabular portion of this work. If space permitted, the projection of the lines indicating the march of temperature and the measure of difference for each year, would throw some valuable light on the several points belonging in this association, and perhaps give us some clue to the great question of the cause of our alternations of cold and warm years.

The Berlin series has not been discussed and compared for the whole period, and only a portion of it has been analyzed by Dove. For so much as has been compared the same results appear as in the cases cited.

It is easy to see that the numerical data for this discussion have a decided expression, and one which cannot be mistaken. For a period of sixty or seventy years they are conclusive, and there is scarcely a theory or assertion that the climate does change, which does not insist that the change has occurred within recent times. But no statistical data of value support such a hypothesis, and all of the best are direct and conclusive against it.

Some facts in regard to the volume of water in the great North American Lakes have been collected in the view that this volume is not permanent. It is known that a range of three or four feet occurs which does not belong to the change of seasons, but is carried over two or three years, like the greater changes of temperature. In Houghton's Geological Report for Michigan* a calculation of a supposed change of level of the great lakes from 1819 to 1838 is made, and the greater height of the water which appears by the observations cited is attributed to an increase in the annual quantity

* Submitted in February, 1839, and published by the Legislature of Michigan, Octavo.

of rain. Taking a measurement in 1819 as a point of departure the following differences were found:—

		Ft.	Inches.				
1819 and 1820		0	00				
1828		2	10	*rise*			
1830		2	10	*same level*			
1836	additional rise,		10		=	3 ft.	8 in.
1837	do.		5		=	4 "	1 "
1838	do.		7		=	4 "	8 "

It appears that these are summer measurements, and that the rise in different summers varies; thus in August, 1838, it was 5 ft. 3 inches above June 1819, in January 1839, but 1 ft. 7 in., in July, 1839, 3 ft. 11 in.; and in January, 1840, but 9 inches. Mr. Houghton goes on to cite the increase in the quantity of rain at Philadelphia in the few years preceding 1840, and to say that if the same increase were supposed for the lake district the water should have risen *twenty-nine* feet in the absence of unusual drainage, or enough under existing circumstances to account for the difference of elevation. But it is shown by Dr. Conrad that the supposed increase at Philadelphia would not appear in accurate measurements, and thus the general point taken by Mr. Houghton fails of support. It is probable that the actual variation was less than that which appears in the measurements cited, and that which did take place was doubtless due to irregular changes in the quantity of rain wholly, and not to any permanent or considerable change.

Observations of the water line of Lake Ontario and Lake Erie show, as examined by Prof. Dewey from observations by many persons, a quite irregular variation, and many changes which cannot be due to profusion or absence of rain. The bed of Lake Ontario is often disturbed by earthquakes and peculiar pulsations also. It is evident that Dr. Houghton's generalization, if intended to indicate a permanent increase of the quantity of water in the lake basins, was drawn too hastily and cannot be sustained.

XVIII. PHYSICAL CONSTANTS:

HOURLY AND MONTHLY VARIATION OF TEMPERATURE AND OF ATMOSPHERIC WEIGHT; BAROMETRIC DETERMINATION OF HEIGHTS, ETC.

THERE are several points of climatological determination which may perhaps be most correctly described as *Physical Constants*, and there are some associated determinations which have much of the peculiar irregularity which characterizes climatological phenomena, while they are still more nearly constants than variable quantities. The daily variations of pressure at the borders of the tropics are least irregular, probably, but the daily change of pressure or of the barometer in temperate latitudes, and particularly the daily curve of temperature, vary in a manner similar to every determination of a climatological character, and they are as difficult to determine positively as other points which are, more than anything else, of the character of generalizations. There is great practical necessity for the best results that may be attained in regard to these hourly changes, and they now enter into many indispensable measurements so much as to require that the best approximations should be at hand for use. The reduction of temperature observations requires the scale of corrections for each hour to be applied before the absolute mean can be known, and this scale we find to vary largely in the variable climates of different American districts.

A sufficient number of these points has been observed to give some view of the distribution of these differences also, and this element of distribution will be made the chief point here, as the best key to an intelligible statement of the whole subject.

Nearly all these constants, or quantities, are of recent determination,* as far as they are known, particularly the nightly curve of temperature and the daily change of pressure, and the observations which have

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* In Humboldt's Personal Narrative, where some horary curves are given for tropical American districts, it is said that the only previous notices of horary observations were published in 1800 and 1801 by M. de Lalande, "to whom I had communicated these successively." They were obtained from "Cumana, Caraccas, the Steppes of Calobozo, and amidst the forests of the Orinoco." (*Pers. Nar.* vol. vi. p. 7.)

been made for the purpose are many of them still unreduced. The extreme labor required to discuss them is one of the greatest obstacles belonging to the case, and even when discussed for single points, it is necessary to group them and to generalize upon them to get at their real significance. The mean change of temperature through the successive hours of the day is scarcely the same for any two months, or for any two districts, and any other result depending on this curve must be considered in view of this fact of irregularity. The choice of hours to represent the true mean temperature depends upon it, and a proper scale of changes will permit observation at any one hour daily to be corrected to an accurate representation of the mean derived from observations taken in every hour of the twenty-four, thus greatly simplifying the labor of observation.

The most important of these primary constants is that of hourly change in the measure of heat through the day, and next is the hourly variation of atmospheric weight, or of the barometer. The elastic force (or weight) of vapor in the air is another important element, and the numerical expression of the relation of the moisture in its average condition to what the air may contain at saturation, constitutes another constant condition.

The absolute weight of vapor, in grains for the cubic foot of air, is a purely physical element, which may take the same shape as a constant when derived from the averages of long periods.

The curve of each of these conditions in the succession of days gives also a set of constants, and the succession of months another. The succession of years may give yet another, if any periodicity is found in the yearly averages, but the consideration of this belongs to the question of Permanence of Climate, which is given a separate place.

A short period of observation will serve to give some outline of each of the results in this case, but the desired absolute mean requires a long period and a careful discussion of the details. In the liberal establishment of British, German and Russian observatories the value of comparison, with the necessary element of distribution of conditions, was fully recognized; and if the results of all these observations were reduced and made comparable the discussion for the temperate latitudes here would be made easy, and close approximations might be attained from comparatively short periods of observation. The Russian observatories best represent our own temperate latitudes, and they are, fortunately, well and widely distributed. St. Petersburg, Helsingfors, Moscow, Kasan, Catherineburg, Tiflis, Barnaoul, Nertchinsk and Pekin, with several others, stretch entirely across Europe and Asia; and Sitka, on the west coast of America, adds a most important

link to the connection with the temporary and permanent observatories in British America, and those of the British Islands.

In the United States there have been several of temporary or permanent establishment, from whose observations these constants could be derived; the first was a partial attempt by Prof. Dewey at Williams College, Mass., in 1816 to 1819; the next Prof. Loomis' observatory at Hudson, Ohio; Capt. Mordecai at Frankford Arsenal, near Philada.; Lieut. Gilliss of the Naval Observatory at Washington; Prof. Bache at Girard College, Philadelphia; the present National Observatory, and others of less importance in which some approach to hourly observation has been made. The long continued observations at Toronto constitute the most valuable American results, and they are also at the point best located to represent a large and peculiar district. In England there is little contrast of positions, and this is sufficiently shown by the observations at Leith, Plymouth, Kew; the Radcliffe Observatory, Oxford; and others, compared with what may be regarded as the great central observatory at Greenwich.

The observatory at Paris represents much the larger share of France, and in Germany and all the west of Europe there is an ample representation.

It is not proposed to undertake all that might and should be done, if the opportunity were sufficient, in determining constants at these points, and in comparing them so as to illustrate the whole field. Such a work is beyond measure laborious, and yet in this, as in every other department belonging to climatology, it is difficult to say what a single or isolated result is worth until many have been examined and compared. It is also difficult to say how far one result may be taken as a general expression, or whether it may answer for a large area or not, and if it may be so employed a good deal of experimenting and examination is still necessary to settle how far it may go. Analogies derived from similar geographical positions on another continent may often help out a partial expression or an imperfect series of observations, and for the interior here such aids must at present be employed.

The constant of horary variation of temperature may have some general distinctions assigned to it, the principal one of which is that the daily curve is sharpest in interior and continental positions, and least abrupt and extreme at maritime positions, and on the west coasts of continents in temperate latitudes. Most of the American observations are so placed in lines as to represent the extremes of this curve, or the highest and lowest points for the day, and they may be used to show this general fact for that reason. A few citations will illustrate this point, all except Sitka being derived from observations for every hour of the twenty-four; the night hours from 11 p. m. to 6 a. m. being omitted at Sitka.

	JANUARY.			JULY.			YEAR.		
	Hour of max. temp.	Hour of min. temp.	Degrees of range.	Hour of max. temp.	Hour of min. temp.	Degrees of range.	Hour of max. temp.	Hour of min. temp.	Degrees of range.
Greenwich, Eng. (Glaisher)	1½ p. m.	6 a. m.	5.9°	1½ p. m.	4 a. m.	13.4°	1¾ p. m.	4 a. m.	10.6°
Greenwich (D.) . . .	2 "	4½ "	5.0	1 "	4 "	13.0	1½ "	4 "	10 4
Plymouth (D.) . . .	..	..	..	..	..	..	1 "	4 "	8.7
Leith, Scotland (D.) . .	..	..	..	..	..	..	2½ "	4½ "	6.1
Toronto, Canada (S.) . .	2½ p. m	4¾ a. m.	6.1	3½ p. m.	4½ a. m.	18 0	2½ "	4¾ "	11.4
Frankford Arsenal, Pa. (D.)	2 "	5¼ "	12.0	2¾ "	3½ "	17.5	2½ "	4¼ "	14 3
Washington, 1841 . .	2½ "	6 "	9.2	4 "	4 "	18.0	2½ "	4¼ "	13.6
Sitka, 1851	2 "	5 ? "	2.6	1¾ "	5 ? "	9.8	1 "	3 ? "	7.3
Pekin, China, 1851 . .	2½ "	6½ "	13.5	2½ "	4½ "	16.8	2½ "	5 "	15.8
Barnaoul, Siberia (D.) .	2 "	2½ "	8.1	2 "	3½ "	19.3	2⅛ "	3¾ "	14.1
Nertchinsk, Asia, 1851 .	2¼ "	7½ "	10.8	2½ "	4¼ "	20.0	2¼ "	4½ "	15.8
St. Petersburg, 1851 . .	1 "	1 "	3.5	2½ "	2¼ "	13.6	1¾ "	2¼ "	7.6

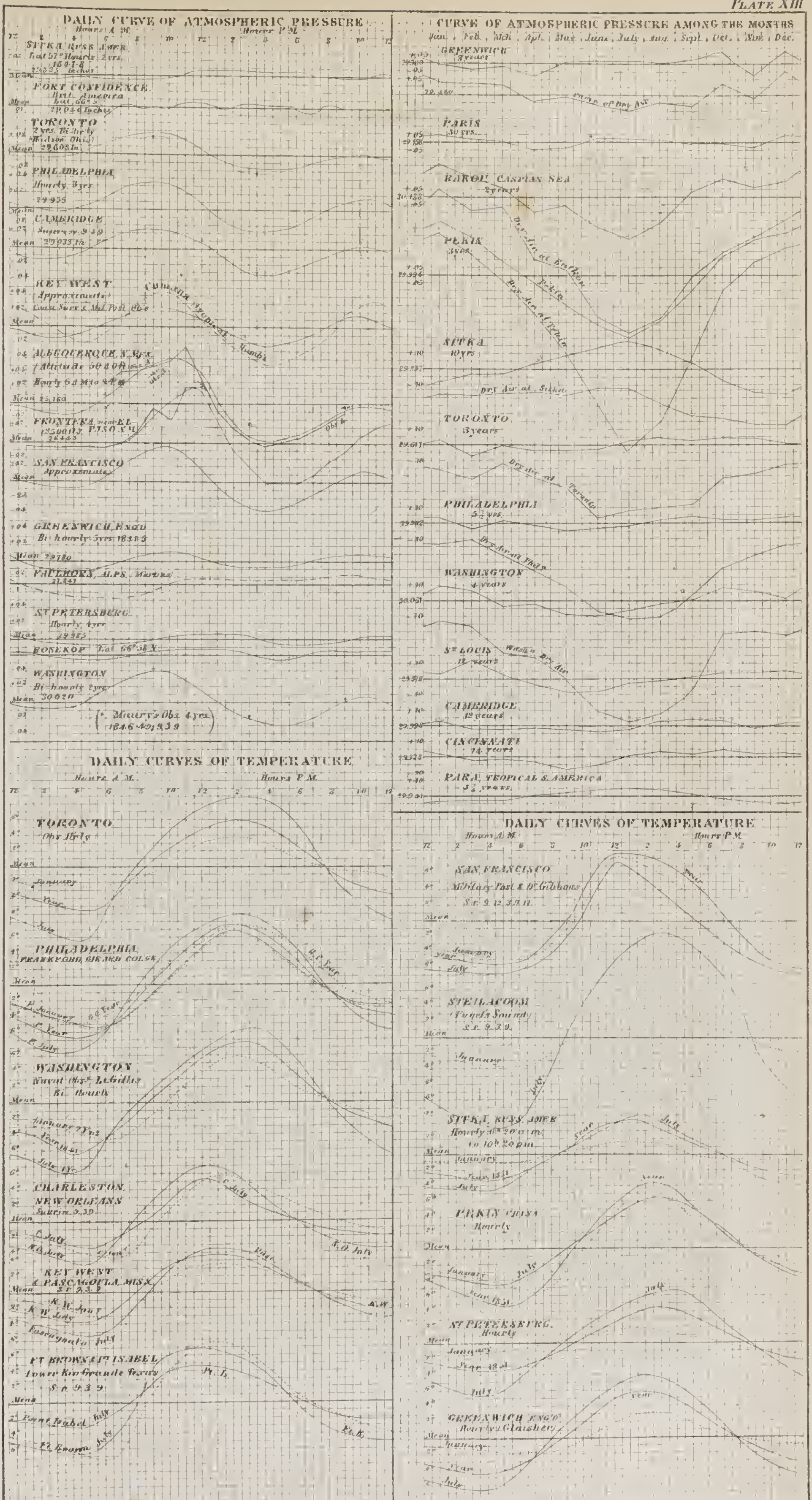
These results resemble those of the mean temperature of the months in being near the natural positions, or those of the sun, on the west coasts of continents and in maritime positions, and in being prolonged one, two, or three hours beyond these natural points in interior and continental positions. In England and at Sitka (probably on all the Pacific coast of the United States also,) it is warmest one hour after the highest position of the sun, or at one to one and a half o'clock afternoon; while at Washington, Philadelphia, and Toronto in the United States, and at Pekin, Barnaoul, and Nertchinsk in Asia and Europe the warmest point is at 2½ to 3 o'clock afternoon—two hours or more later. The coldest hour of the twenty-four changes its position similarly, though it is always two and a half to five hours after midnight. Though a much more thorough summary of observations is necessary to settle the precise positions of these points, the above may be sufficient to establish the point under consideration which may be stated to be, *first; that the warmest and coldest hours of the day are always removed one to six hours from the natural points of noon and midnight;*

Second; that the warmest hour of the twenty-four is nearest the natural point on the west coasts of the continents in temperate latitudes, and there it is usually at one to one and a half o'clock afternoon; while it is farthest removed from the natural point in the interior and east coasts being there two and a half to three and a half hours afternoon.

Third; that the coldest hour of the twenty-four is always farther from midnight than the warmest hour is from noon; varying, as in the first case, from three o'clock to six or seven o'clock morning.

The difference of latitude of course makes a difference in the morning hours, as in England, and at St. Petersburg and Sitka, the sun rises earlier than at Washington; but the effect of radiation and of other natural causes of refrigeration is greatly increased in the continental positions, and it goes on to a later hour. The increase of heat is similarly prolonged, particularly so in the warmer months and lower latitudes; and this extension in the central part of the United States is sufficient to keep up the heat nearly to sunset, and to throw the highest point at 4 o'clock, with a very slight fall from that hour to 6 o'clock, afternoon. The curves of Plate XIII, projected in greater part from hourly observations, and in part from a graphic interpolation between observations at three or four hours daily, will represent the daily changes of temperature for as much of the United States in temperate latitudes, with its equivalents elsewhere, as has been observed sufficiently to permit any illustration.

A comparison of these curves will at once show the differences just remarked; Toronto, Philadelphia, Washington, and Pekin, on the east of the great continental areas, have the maximum points of the daily heat thrown forward to 3 or 4 o'clock p. m., while Greenwich, Sitka, and San Francisco particularly, have the greatest heat of the day much earlier and within one or two hours of the natural point of 12 o'clock. All southern portions in the United States are similar, and Key West, which approaches nearest the tropics, shows its maximum heat at one o'clock afternoon. San Francisco


DAILY CURVE OF ATMOSPHERIC PRESSURE
Hours A.M.
Hours P.M.
SITKA RUSS AMER.
FORT CONFIDENCE
TORONTO
PHILADELPHIA
CAMBRIDGE
KEY WEST
ALBUQUERQUE N. Mex.
FRONTERA near EL PASO
SAN FRANCISCO
GREENWICH ENGD
FAULHORN, ALPS
ST PETERSBURG
BOSEKOP
WASHINGTON
CURVE OF ATMOSPHERIC PRESSURE AMONG THE MONTHS
Jan. Feb. Mch. Apl. May. June. July. Aug. Sept. Oct. Nov. Dec.
GREENWICH
PARIS
BAKOU, CASPIAN SEA
PEKIN
SITKA
TORONTO
PHILADELPHIA
WASHINGTON
ST LOUIS
CAMBRIDGE
CINCINNATI
PARA, TROPICAL S. AMERICA
DAILY CURVES OF TEMPERATURE
Hours A.M.
Hours P.M.
TORONTO
PHILADELPHIA
WASHINGTON
CHARLESTON
NEW ORLEANS
KEY WEST
& PASCAGOULA MISS.
FT BROWN & PT ISABEL
DAILY CURVES OF TEMPERATURE
SAN FRANCISCO
STEILACOOM
SITKA, RUSS. AMER.
PEKIN CHINA
ST PETERSBURG
GREENWICH ENGD

and Lower Texas are affected by local causes, a strong day wind from the sea existing at both localities, and all along the coasts they represent. In the monthly means the hour is thrown later by the occurrence of days in which the local cause is not felt, and there are enough of these in each month to bring the maximum hour nearly to 12 o'clock.

The authorities for the positions given these curves (Plate XIII) are the following;

Toronto; Col. Sabine's scale of corrections for each hour, calculated from constants derived from six years of hourly and bi-hourly observations, 1842 to 1848; in Phil. Trans. Roy. Soc. 1853.

Philadelphia, and Frankford Arsenal; Prof. Bache's observations at Girard College hourly and bi-hourly in 1842, and from July 1843 to July 1845. At Frankford Arsenal, Maj. Mordecai's hourly observations in the Journal of the Franklin Institute, here taken from Dove's scale of corrections in Proceedings of British Association for 1848.

Washington; Lieut. Gillis' bi-hourly observations in 1841 and 1842 at the Naval Observatory, from the tables of his Report.

Charleston: From the Military Post Observations at Fort Moultrie, near Charleston, at sunrise, 9 a. m., 3 p. m., and 9 p. m.; summary for twelve years, 1843 to 1854.

Key West; Military Post Observations at the same hours for eight years, 1843 to 1845, and 1850 to 1853.

Pascagoula, Miss.; The July curve for this point of exposed coast is from Military Post Observations for July and August during six years, 1848 to 1853.

New Orleans; Military Post Observations for eight and ten years, for some part of the time taken from the posts near New Orleans, Forts Pike and Wood.

Point Isabel, coast at mouth of Rio Grande; from Military Observations in 1849 and 1853.

Fort Brown (near Matamoras); Military Post Observations for 1850 to 1854.

San Francisco; The averages derived from the Military Observations for three years ending with 1854, and including June and August for two years of the summer, and Dr. Gibbons' observations (*Amer. Jour. of Science*) for four years 1851 to 1854. In these last the hour of 12 o'clock, noon, was always observed, and 10 or 11 p. m. The military observations were at the usual hours.

Steilacoom, Puget's Sound; Military Observations for five years 1851 to 1854.

Sitka; Hourly observations from 6h. 20′ a. m. to 10h. 20′ p. m. at the Russian Observatory; from the tables for 1851 in Annales de l'Observatoire Physique Central de Russie for 1851, St. Petersburg, 1853.

Pekin, China; Hourly observations at the Russian Observatory, the tables are in the volume and for the year quoted at Sitka.

St. Petersburg; Hourly, for the same year, and from the same source.

Greenwich; England; from Glaisher's corrected scale of hourly differences, derived from several years of hourly observations, in Phil. Trans. Roy. Society for 1850.

The following are the numerical corrections used for the several hours at the principal points, given however, with their natural signs, or the range above the mean being marked as excess, and that below the mean as deficiency.

HRS.	GREENWICH.			TORONTO.			PHILADELPHIA. (FRANKFORD.)			WASHINGTON.			SITKA.			ST. PETERSBURG.		
	Jan.	Jul.	Yr.	Jan.	Jul.	Yr.	Jan.	Jul.	Yr.	Jan.	Jul.	Yr.	Jan.	Jul.	Yr.	Jan.	Jul.	Yr.
A. M.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	—0.9	—5.5	—3.8	—2.6	—6.8	—4.8	—3.0	—6.9	—4.8	..	..	..	..	..	..	—1.4	—5.3	—2.4
2	1.2	6.0	4.2	3.1	7.6	5.5	3.4	7.9	5.5	—2.9	—7.2	—4.2	..	..	..	—1.5	—5.8	—2.9
3	1.3	6.4	4.6	3.4	8.5	5.9	4.1	8.6	6.2	..	..	..	..	..	..	—1.5	—6.5	—3.1
4	1.6	6.6	4.8	3.4	8.7	5.9	4.8	8.6	6.6	—3.2	—8.5	—6.2	..	..	..	—1.4	—6.7	—3.3
5	1.8	6.2	4.7	2.9	8.8	5.6	5.2	7.6	6.4	..	..	..	..	..	..	—1.3	—5.5	—3.5
6	1.9	4.5	3.8	1.9	8.3	4.7	5.1	5.7	5.4	—4.2	—5.0	—4.4	—1.0	—3.1	—2.3	—1.0	—4.1	—3.1
7	1.9	2.5	2.6	1.0	6.7	3.1	4.2	3.0	3.7	..	..	..	—0.6	—1.8	—1.4	—0.8	—2.2	—2.3
8	1.5	0.0	1.3	0.4	3.3	1.2	2.8	0.2	1.5	—3.5	—0.5	—1.3	—0.3	—0.7	—0.4	—0.5	—0.3	—1.8
9	1.0	+2.0	+0.5	0.0	+0.8	+0.4	0.8	+2.4	+0.8	..	..	..	+0.5	+0.3	+0.7	—0.1	+1.0	—0.3
10	0.2	4.0	2.3	+0.2	3.1	1.5	+1.4	4.4	2.8	+0.3	+2.8	+2.0	+0.6	+1.8	+1.0	+0.3	+2.4	+0.8
11	+1.3	5.4	3.9	0.6	4.3	2.3	3.5	5.9	4.6	..	..	..	+1.3	+2.2	+2.7	+0.8	+3.7	+1.2
12	2.3	6.4	5.1	0.9	5.4	3.0	5.2	7.1	6.0	+3.3	+5.5	+5.1	+1.4	+3.2	+4.2	+1.4	+4.5	+2.9
P. M.																		
1	2.9	6.7	5.7	1.6	6.4	3.5	6.4	8.1	7.1	..	..	..	+1.6	+4.0	+4.5	+1.9	+5.5	+3.6
2	3.0	6.7	5.8	2.0	7.3	4.1	6.8	8.7	7.7	+5.8	+7.8	+7.2	+1.5	+5.0	+4.3	+2.0	+5.6	+4.0
3	2.5	6.5	5.3	2.1	7.9	4.5	6.6	8.9	7.7	..	..	..	+1.2	+4.8	+3.7	+1.7	+6.0	+4.2
4	1.9	5.8	4.4	2.3	8.6	5.0	5.7	8.3	7.0	+5.3	+9.4	+7.3	+0.8	+4.0	+2.9	+1.3	+6.8	+4.0
5	1.1	4.9	3.2	2.4	9.1	5.3	4.3	6.7	5.6	..	..	..	+0.2	+2.9	+2.0	+1.0	+6.1	+3.5
6	0.6	3.5	2.0	2.6	9.2	5.5	2.6	4.5	3.6	+1.9	+6.0	+4.0	—0.1	+1.5	+0.9	+0.8	+4.0	+2.4
7	0.3	1.5	0.6	2.1	6.2	4.6	0.8	1.9	1.4	..	..	..	—0.2	—0.1	+0.0	+0.5	+2.5	+1.5
8	—0.1	—0.3	—0.6	2.2	2.7	3.1	—0.7	—0.6	—0.6	+0.6	+0.0	+0.3	—0.3	—1.7	—1.2	+0.1	+0.5	+0.4
9	0.4	1.9	1.5	1.9	—0.1	1.2	1.7	2.6	2.2	..	..	..	—0.5	—2.6	—1.7	—0.1	—1.2	—0.3
10	0.6	3.3	2.3	0.7	2.3	—0.8	2.3	4.0	3.2	—0.6	—3.8	—1.6	—0.7	—3.4	—2.2	—0.5	—2.4	—1.2
11	0.7	4.2	2.9	—0.6	4.1	2.5	2.5	5.0	3.8	..	..	..	..	..	..	—0.7	—3.6	—1.6
12	1.0	5.0	3.4	1.8	5.6	3.8	2.7	5.9	4.2	—2.5	—6.5	—3.2	..	..	..	—1.1	—4.5	—2.2

HOURS.	CHARLESTON.		KEY WEST.		PASCA.	NEW ORLEANS.		PT. ISABEL	FT. BROWN.		SAN FRANCISCO.			STEILACOOM.	
	Jan.	July.	Jan.	Jul.	July.	Jan.	July.	July.	Jan.	Jul.	Jan	Jul.	Yr	Jan.	July.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Sunrise	—4.5	—2.8	—2.7	—3.6	—5.2	—5.8	—5 3	—3 3	—6.7	—6.7	—4.4	—7.0	—5.3	—3.3	—12.0
9 a. m.	—0.6	+0.1	+0.4	+1.5	—1.9	+0.7	+2.6	+2.2	+1.7	+3.3	—0.5	—1.2	+0 5	—0.2	+0.4
12 m.	..	..	..	..	..	..	..	..	..	..	+8.0	+7.7	+9.4	..	..
3 p. m.	+5.1	+2.9	+3.1	+3.6	+4.9	+6.7	+5.1	+3.2	+6.3	+5.3	+6 6	+3.8	+7 5	+3.5	+13.2
9 p. m.	—0.1	—1.1	—0.8	—1.5	—1.6	—1.6	—2.4	—1.8	—1.3	—3.8	—2.2	—5.5	—3 7	—0.1	—1.8

The most remarkable and important practical distinction exists on the coast of California, in the cold midday of all the summer months at positions exposed to the sea winds. This reduced temperature affects cultivation largely, and along the immediate coast few of the peculiar staples of the eastern States ripen, or not those of tropical associations, particularly Indian corn. The sensible climate is singularly changed, and overcoats become indispensable in the middle of a July day at a latitude where the mean annual temperature exceeds that of Baltimore, and where the mean of winter is nearly equal to that at Charleston. The increase of heat in the morning hours is very rapid here until ten or eleven o'clock, and so much of the curve is even sharper than in the Atlantic States, but from eleven or twelve o'clock the heat steadily declines, standing several degrees lower for the whole afternoon than in any other district of the same latitude.

The coasts of the Gulf of Mexico are similarly cooled at midday, though in a much less measure. Usually the coast fully open to the sea breeze is as warm at 10 o'clock, morning, as at any subsequent hour, the temperature remaining nearly the same for several hours, or nearly until four o'clock in summer. The reduction is most extreme on the coast of Texas, where, for the distance from Galveston to the Rio Grande, the sea breeze becomes a monsoon for four or five months. This reduced curve greatly improves the sensible climate of the States bordering the Gulf, and saves the districts nearest the sea from what would prove a dangerous excess of heat with the large quantity of moisture present there.

ABSOLUTE POSITION OF THE TEMPERATURE CURVE.

The most important practical feature of the analysis of the yearly temperature curve is its reference to a positive base, and the indication of the seasons relative to that. Using the terms which express the divisions important to practical interests, the winter, spring, summer and autumn, vary greatly in position in the curve, and in duration. The greatest difficulty is in getting positive definitions for these seasons in the means of temperature, because like measures do not always, or positively, express like conditions, particularly when the extremely contrasted districts are compared. December and January at New Orleans are equal in temperature to May in the New England States, yet vegetation is very active during most of the month at the north, and almost wholly dormant at New Orleans. February, with a mean two or three degrees above that of either of the first named months, is the first spring month at the borders of the Gulf, though vegetation is far less rapid than in May at Philadelphia. In some of the forest

trees the movement of sap and the swelling of buds are active in a month of a mean temperature of 30°, in high latitudes.

The transition seasons of spring and autumn are so abrupt in most parts of the United States as to be almost universally described as very short. They are particularly so in Canada, and Volney expresses the same idea in his customary form of exaggeration in saying that "in all North America there is no season answering to spring." The entire period of leaf expansion from the first swelling of the buds is, however, never less than sixty days, and in the central and southern districts from seventy to nearly ninety. The period of declining vegetation is equally prolonged there, though it is very short and abrupt in the extreme northern districts, not reaching fifty days in Canada.

Though the requisite definition is extremely difficult of attainment, and cannot be made in the form of a temperature constant for but a single locality or single line, the effort will be made in the following table to define the constants of the seasons;—the leafing, flowering, fruiting, and dormant season,—for all the more important divisions of our climate. To these the variable measures of temperature actually existing will be attached in a separate list, to show the variable signification of temperature measures alone.

Mr. Poole has assumed the mean annual temperature at Albion Mines, Nova Scotia, as a fixed line from which to measure the limits of the seasons, taking the extreme range of 60° which occurs there as the quantity to be divided equally for the seasons, each having a march of 20°. The annual mean is there 42°, and the extremes of spring and autumn, therefore, 32° and 52°; while the spaces having a higher and a lower temperature fall into the summer and winter. If the curve between the monthly means at each station were projected, and the line then cut by a correct standard for each district, the seasons could so be divided for every part of the United States, but the greatest difficulty is found in fixing a point, and in measuring the departures which should limit the intermediate seasons. The mean of 42° is far from correctly representing the spring even at Boston, and the dormant winter at Washington, which covers a period of at least three months, has no single month so low as 32°. The daily mean of 32° which marks the beginning of spring at Nova Scotia on the first of April must be changed to 42° nearly at Washington, which point is reached on March 4th.

Again, the winter is dormant nearly a month at Charleston and Savannah, with the mean temperature 50° and 52°; though perhaps this can be said of annual vegetation only, and of that liable to injury by frosts. The same condition prevails over the entire coast of the Gulf in the latitude of Mobile and New Orleans, and even much lower, in Texas, since the winter at Matamoras and the mouth of the Rio Grande is one of more or less complete suspension of the growth of annuals and tender plants, though so low as the 26th parallel, or four degrees of latitude south of New Orleans. Here the mean temperature does not get below 60°; at New Orleans it is 54°.5, and at Mobile 53°. There are thus three periods equally distant, which may be assigned to districts equally separated, as *the points of departure for the advance of temperature which revives annual vegetation, and constitutes the spring;* and these have the tempera-

tures of 32° for Nova Scotia and the northern lake district; 42° for Washington, Cincinnati, and St. Louis; and 52° for the vicinity of the Gulf coast at a point sufficiently removed to avoid the merely maritime effect. In California the point of 52° marks the spring at San Francisco and southward, and in Oregon it falls to 42°.

In the application of these necessarily empirical measures there may be many irregularities, but the effort to apply them may serve to assist inquiry, and to form some definite basis for this somewhat singular discussion. The object is to define the periods of the natural constants, which constitute, in the words of Howard, "the germinating, leafing spring; the flowering summer; the fruit-bearing autumn; and the dormant, naked winter." In the following table these points are in some cases definitely, and in others roughly indicated.

Date of Commencement and End of Each Season, with the number of days' duration of each.

	SPRING.		SUMMER.		AUTUMN.		WINTER.	
Albion Mines,[1] N. Scotia	Mch. 28–June 1	66	June 2–Sep. 25	116	Sep. 26–Nov. 27	63	Nov. 28–Mch. 27	120
Quebec	Apl. 10–June 10	62	June 11–Sep. 15	97	Sep. 16–Nov. 1	47	Nov. 2–Apl. 9	159
Toronto	Apl. 1–June 10	71	June 11–Sep. 13	95	Sep. 14–Oct. 22	39	Oct. 23–Mch. 31	160
Burlington, Vt. . .	Mch. 30–June 4	67	June 5–Sep. 20	108	Sep. 21–Oct. 23	33	Oct. 24–Mch. 29	157
Boston	Mch. 20–June 1	74	June 2–Sep. 20	111	Sep. 21–Nov. 5	46	Nov. 6–Mch. 19	134
New Bedford . . .	Mch. 15–June 1	79	June 2–Sep. 20	111	Sep. 21–Dec. 1	72	Dec. 2–Mch. 14	103
New York (City) . .	Mch. 15–June 1	79	June 2–Sep. 20	111	Sep. 21–Nov. 15	56	Nov. 16–Mch. 14	119
Albany	Mch. 20–June 1	74	June 2–Sep. 15	106	Sep. 16–Nov. 1	47	Nov. 2–Mch. 19	138
Rochester . . .	Mch. 20–June 4	77	June 5–Sep. 15	103	Sep. 16–Nov. 1	47	Nov. 2–Mch. 19	138
Pittsburg . . .	Mch. 15–May 20	67	May 21–Oct. 1	134	Oct. 2–Nov. 15	45	Nov. 16–Mch. 14	119
Philadelphia . . .	Mch. 15–May 18	65	May 19–Oct. 1	136	Oct. 2–Nov. 20	50	Nov. 21–Mch. 14	114
Baltimore . . .	Mch. 8–May 15	69	May 16–Oct. 1	139	Oct. 2–Nov. 20	50	Nov. 21–Mch. 7	107
Washington . . .	Mch. 3–May 15	74	May 16–Oct. 3	142	Oct. 4–Nov. 25	52	Nov. 26–Mch. 2	97
Norfolk	Feb. 18–May 3	74	May 4–Oct. 10	161	Oct. 11–Nov. 30	51	Dec. 1–Feb. 17	79
Charleston . . .	Feb. 1–Apl. 15	74	Apl. 16–Oct. 20	189	Oct. 21–Dec. 10	50	Dec. 11–Jan. 31	52
St. Augustine . . .	Jan. 20–Apl. 1	70	Apl. 2–Nov. 10	224	Nov. 11–Dec. 15	35	Dec. 16–Jan. 19	35
Pensacola . . .	Feb. 1–Apl. 15	74	Apl. 16–Oct. 20	189	Oct. 21–Dec. 10	50	Dec. 11–Jan. 31	52
Mobile	Feb. 1–Apl. 10	69	Apl. 11–Oct. 25	199	Oct. 26–Dec. 15	50	Dec. 16–Jan. 31	47
Huntsville, Ala. . .	Mch. 1–May 1	62	May 2–Oct. 5	157	Oct. 6–Nov. 25	51	Nov. 26–Feb. 28	95
New Orleans . . .	Feb. 1–Apl. 15	74	Apl. 16–Oct. 20	189	Oct. 21–Dec. 10	50	Dec. 11–Jan. 31	52
Nachitoches . . .	Feb. 14–Apl. 15	61	Apl. 16–Oct. 15	184	Oct. 16–Nov. 25	40	Nov. 26–Feb. 13	80
Brownsville, Texas .	Jan. 25–Mch. 31	66	Apl. 1–Nov. 1	215	Nov. 2–Dec. 15	44	Dec. 16–Jan. 24	40
San Antonio, Texas .	Feb. 1–Apl. 15	74	Apl. 16–Nov. 1	200	Nov. 2–Dec. 1	30	Dec. 2–Jan. 31	61
Fort Washita . . .	Feb. 14–Apl. 30	76	May 1–Oct. 4	157	Oct. 5–Nov. 20	47	Nov. 21–Feb. 13	85
Fort Gibson . . .	Feb. 20–May 4	74	May 5–Oct. 1	156	Oct. 2–Nov. 15	49	Nov. 16–Feb. 19	96
St. Louis	Mch. 4–May 15	73	May 16–Sep. 28	136	Sep. 29–Nov. 10	53	Nov. 11–Mch. 3	113
Cincinnati . . .	Mch. 1–May 15	76	May 16–Oct. 1	139	Oct. 2–Nov. 15	55	Nov. 16–Feb. 28	105
Marietta, Ohio . .	Mch. 5–May 20	77	May 21–Oct. 1	134	Oct. 2–Nov. 15	55	Nov. 16–Mch. 4	109
Detroit	Mch. 16–June 5	82	June 6–Sep. 15	102	Sep. 16–Nov. 10	66	Nov. 11–Mch. 15	125
Fort Brady . . .	Apl. 5–June 15	72	June 16–Sep. 10	87	Sep. 11–Oct. 22	52	Oct. 23–Apl. 4	164
Fort Snelling . . .	Mch. 21–June 8	80	June 9–Sep. 15	99	Sep. 16–Oct. 23	38	Oct. 24–Mch. 20	148
Ft. William, L. Superior	Apl. 20–June 15	57	June 16–Sep. 10	87	Sep. 11–Oct. 23	43	Oct. 24–Apl. 19	178
Saskatchawan, Cumb'd H.	Apl. 8–June 10	63	June 11–Sep. 8	90	Sep. 9–Oct. 15	37	Oct. 16–Apl. 7	175
Martiu's Falls, Brit. Am[2]	Apl. 15–June 15	62	June 16–Sep. 1	78	Sep. 2–Oct. 10	39	Oct. 11–Apl. 14	186
Ft. Franklin, Gt. Bear L.[3]	May 6–June 15	40	June 16–Aug. 31	77	Sep. 1–Sep. 30	30	Oct. 1–May 5	218
Fort Leavenworth . .	Mch. 10–May 15	67	May 16–Sep. 23	131	Sep. 24–Nov. 10	48	Nov. 11–Mch. 9	119
Fort Kearney . . .	Mch. 15–May 15	62	May 16–Sep. 15	123	Sep. 16–Nov. 1	47	Nov. 2–Mch. 14	133
Fort Laramie . . .	Mch. 1–June 1	93	June 2–Sep. 15	106	Sep. 16–Nov. 15	61	Nov. 16–Feb. 28	105
Great Salt Lake . .	Mch. 15–June 1	79	June 2–Sep. 10	101	Sep. 11–Nov. 1	52	Nov. 2–Mch. 14	133
Ft. Massachusetts, N. M.	Apl. 1–June 10	71	June 11–Sep. 1	83	Sep. 2–Oct. 26	55	Oct. 27–Mch. 31	156
Santa Fe	Mch. 1–June 1	93	June 2–Sep. 15	106	Sep. 16–Nov. 15	61	Nov. 16–Feb. 28	105
Ft. Fillmore, n'r El Paso	Feb. 1–Apl. 30	79	May 1–Sep. 30	123	Oct. 1–Dec. 5	66	Dec. 6–Jan. 31	57
San Diego . . .	Jan. 26–Apl. 15	80	Apl. 16–Oct. 15	183	Oct. 16–Dec. 15	61	Dec. 16–Jan. 25	41
San Francisco . . .	Feb. 10–May 31	111	June 1–Oct. 15	137	Oct. 16–Dec. 1	47	Dec. 2–Feb. 9	70
San Joaquin (Ft. Miller)	Feb. 1–Apl. 15	73	Apl. 16–Nov. 1	199	Nov. 2–Dec. 10	39	Dec. 11–Jan. 31	52
Fort Vancouver . .	Feb. 20–June 1	102	June 2–Sep. 15	106	Sep. 16–Dec. 1	77	Dec. 2–Feb. 19	80
Puget's Sound, Steilac'm.	Feb. 20–June 10	111	June 11–Sep. 15	97	Sep. 16–Nov. 20	66	Nov. 21–Feb. 19	91
Lapwai, Walla-Walla .	Mch. 1–June 1	93	June 2–Sep. 15	106	Sep. 15–Nov. 10	56	Nov. 11–Feb. 28	110
Fort Owen, Wash. Ter. .	Mch. 15–June 1	79	June 2–Sep. 1	92	Sep. 2–Nov. 1	61	Nov. 2–Mch. 14	133
Fort Benton, Mo. Ter. .	Mch. 15–June 1	79	June 2–Sep. 15	106	Sep. 16–Nov. 1	47	Nov. 2–Mch. 14	133
Sitka, Russian Amer. .	Mch. 1–June 15	107	June 16–Sep. 1	78	Sep. 2–Nov. 1	61	Nov. 2–Feb. 28	119

[1] The definitions at Albion Mines are by Mr. Poole, and they are seen by a general comparison of districts to be too low to represent the desired conditions. The measures are necessarily empirical, and it is clear they should be 2° to 6° higher.

[2] Richardson.

[3] This is an extreme station of British America which is so far west as to have a regular succession of seasons. It is near the Arctic Circle, lat. 65° 12′, long. 123° 13′, alt. 500 feet.

Measures of Temperature assumed as the Limits of the Seasons in the Various Districts of the Table.

	Spring.	Autumn.		Spring.	Autumn.
	° °	° °		° °	° °
Fort Franklin, Gt. Bear	36. to 52.	55.8 to 34.3	Fort Gibson	44.4 to 64.	67.5 to 49.8
Albion Mines	32. " 52.	52. " 32.	St. Louis	40.5 " 66.	62.8 " 43.
Quebec	36.5 " 62.	56. " 38.	Cincinnati	38.8 " 63.6	59.6 " 42.5
Toronto	36. " 60.	57. " 34.	Marietta, Ohio	40. " 63.	63.0 " 42.3
Burlington, Vt	36.5 " 61.	57.5 " 33.	Detroit	35.5 " 62.	60. " 39.5
Boston	38. " 61.5	60.5 " 34.5	Ft. Brady	34. " 58.4	56. " 41.
New Bedford, Mass.	36. " 59.	60. " 37.	Ft. Snelling	34. " 56.	59. " 43.
New York	38. " 63.8	63.5 " 43.	Ft. William, L. Sup.	32.5 " 58.	50. " 36.
Albany	37. " 63.8	61.4 " 44.2	Saskatch'n, Cumb'd. H.	30. " 60.	49. " 33.
Rochester	35.5 " 62.	60.3 " 43.2	Ft. Leavenworth	40.5 " 63.	62.8 " 43.
Pittsburg	39. " 62.	62.2 " 40.	Ft. Kearny	35. " 60.	64. " 41.8
Philadelphia	40.5 " 62.	61.0 " 42.	Ft. Laramie	34.5 " 61.7	64.2 " 35.8
Baltimore	41. " 63.	61.7 " 43.	Great Salt Lake	38. (?) " 66. (?)	
Washington	42. " 63.5	60. " 42.	Ft. Mass., N. M.	38. " 56.	57. " 37.
Norfolk	43. " 62.	63.5 " 47.	Santa Fé	38.5 " 62.	62. " 38.6
Charleston	51. " 65.	66. " 53.	Ft. Fillmore, n'r. El Paso	46.4 " 67.7	70.8(?) 48.
St. Augustine	57. " 66.	66. " 57.	San Diego	52. " 61.2	65.5 " 52.
Pensacola	54.5 " 68.	68.5 " 56.5	San Francisco	50.5 " 56.	58. " 52.7
Mobile	57. " 69.	67.5 " 56.5	San Joaquin, Ft. Miller	50. " 63.	61.5 " 50.
Huntsville, Ala.	47. " 64.	63. " 46.5	Ft. Vancouver	42. " 61.	60.8 " 42.
New Orleans	55. " 69.	68.4 " 56.5	Steilacoom	41.5 " 60.	58. " 43.
Nachitoches	52. " 67.4	66. " 54.	Lapwai n'r. Walla Walla	40.5 " 63.	64. " 42.
Brownsville	60.5 " 72.	71. " 62.	Ft. Owen, Wash. Ter.	39.5 " 60.2	64.6 " 40.
San Antonio	55.4 " 69.4	67. " 56.	Ft. Benton, Mo. Ter.	36.5 " 63.	61.0 " 42.
Fort Washita	47.0 " 66.4	67.5 " 50.	Sitka, Russ. Amer.	38. " 55.	56.5 " 43.6

In review of these statistics, which cannot be far from accuracy, though necessarily estimates and approximations, it is singular to observe that the range of temperature marking the awakening of vegetation is so great as from 30° to 60°—the point being at 30° on the Saskatchawan, and at 60° at Matamoros, on the lower Rio Grande. This last is the lowest point to which it may be said that the dormant winter extends on this continent, and it is nearer the tropics than any similar point of the eastern continent at sea level. The leafing process which we define as the spring, is also completed at a temperature considerably variable, ranging from 55° at Sitka and in Nova Scotia to 70° or over at Matamoros; but the limit is not abrupt at the borders of the Gulf, or in any semi-tropical districts.

A summer interval then succeeds, varying from 78 to 215 days in duration in the range from the north shore of Lake Superior to lower Texas; the average in middle latitudes, as at Washington and St. Louis, being 140 days. The commencement of autumn is quite similar to the close of spring in its mean of daily temperature, except at the colder interior districts having the shortest summer, where vegetation struggles forward under a temperature 10° lower at this critical period. The earth is warmer than the atmosphere in this district under the rapid decline of temperature, and this assists the preservation of activity in the vegetation, which continues at an atmospheric temperature of 50°. The highest extreme is 71° in Texas, and the average 63° for the middle latitudes. The completion of this period of declining vegetation, or its absolute suspension in winter, varies much as the opening of spring varies, and it has the extremes at 32° and 62°, with the average for the latitude of Washington at 42°. The period of this decline to winter is everywhere less than that of the spring, and it is most prolonged at the cooler maritime positions, where, as at Nova Scotia, New Bedford, and Vancouver, the most extended periods appear, both relatively and absolutely. It is variable from peculiar causes in some districts, as at San Antonio, where the summer is prolonged by local influences, and winter at length comes abruptly; Burlington, Vt., St. Augustine, and Nachitoches, are instances also.

The winter is, of course, only defined relatively, and it is far from being a complete suspension of vegetation at the borders of the Gulf, yet it is much more completely such everywhere east of the Rocky Mountains than the European winter, or that of the Pacific coast. At London meadows are not unfrequently green for the entire winter, and on all the west coasts of Europe, even to Norway, the earth rarely freezes, and most perennials retain some appearance of growth. It is so on the Pacific coast, and at Puget's sound the grass scarcely ceases to grow. But in the eastern United States vegetation is thrown into a dormant state, almost uniformly, to the very borders of the Gulf in Louisiana, and the extensive plains and marshes of succulent grasses and canes there, most of which are liable to destruction by frost, become blackened with the dead mass destroyed by the frosts and cold winds of December. At intervals this is a very complete establishment of winter according to the ideas attached to that season in the middle latitudes, though at others it may fail to occur.*

The lowest mean daily temperature belonging to this position as a constant is 54°, and the boundaries of the dormant period cannot be below 55°; which are the highest assigned to any winter period elsewhere, except at St. Augustine, and Brownsville (Matamoros) of the lower Rio Grande. At these last points the winter is irregular, and perhaps its indication as a constant is in some measure problematical.

The winter period is always less than that of summer,—it is least at St. Augustine and Brownsville, 35 to 40 days; and greatest at the north of Lake Superior, 178 to 186 days. The whole period of sensible winter, as it may be called, or of the existence of snow and ice in the northern districts, and the absence of grasses for the support of cattle, is of course much greater, and it may be set down as including half to two-thirds of the spring, or 30 to 45 days in addition. But during this period many forms of vegetable life are extremely active, particularly the sap of trees, and of the roots of grasses, and winter grains, even beneath a covering of snow.

Though the matter is somewhat difficult to place appropriately, like that in many other branches of climatology, it may be proper to give here some leading phenomena marking the progress of the seasons in the principal districts. The temperature curve is a physical constant of the most positive character, though it can only be defined by an extended series of observations, and it may rarely or never be evolved from any formula expressive of a general law. Like the temperature distribution in latitude, no one district may be taken as a representative of the whole, or of any one sufficiently extended to make the use of a formula at all serviceable beyond the purposes of interpolation in an incomplete series. Every aid to the definition drawn from sensible phenomena becomes important, therefore, to assist the explanation of temperature measures, as we find these to stand at very different positive points in different latitudes. The leafing, and the fall of leaf from deciduous trees of the same species, are at very different temperatures on the Saskatchawan and at Washington respectively, for instance, and the significance of these respective temperatures must be defined by reference to the phenomena themselves.

Richardson has given, in his Arctic Expedition in search of Sir John Franklin, several admirable briefs of the "phenomena indicating the progress of the seasons" at various points in British America within the temperate latitudes, which may be introduced here in a condensed form, as the preface to those cited for the United States. The first is a list of the "*Phenomena indicating the Progress of the Seasons*" at Martin's Falls, midway between Lake Superior and Hudson's Bay, lat. 51° 32′, long. 86° 39′, on Albany River. The three months Dec. to Feb. he designates as here "dead winter months;"—some large owls, and a few ptarmigan arriving from the north, remain. At

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* See Darby's various description of Louisiana. "The prairies below 30° north latitude have often the dry stubble like aspect of fields from which the grain has been cut." (Geog. and Stat. Descrip. of La., &c., p. 78.)

the close of March the willow-grouse go northward, and the sun has some effect to settle the snow; in April insects come through it on mild days, and a crust forms, snow birds come early in this month, and uear the close the Canada goose aud some ducks, with the robiu (red-breasted thrush).

At the first of May the snow melts rapidly, the ground appeariug; wild geese and ducks pass northward, and small birds appear. At the middle of the month the early forest buds appear; the large rivers break up, and fish ascend them; frogs are heard, and mosquitoes appear. At the last of the month the aspen and early forest-trees are in leaf, and the last of the spring birds arrive. At the first of June woodland flowers appear, but night frosts are common, and the ground is still frozen at a foot below the surface. By the middle of the month the latest shrubs and trees are in leaf, and at the close of it the full summer, with its close heat and profusion of insect life, is established. July is the warmest month,—the rivers are low, cattle feed in the night to avoid insects, strawberries ripeu, and sturgeon return to deep water. In August sultry weather occurs, with thuuderstorms followed by chilly nights. Pigeons and young geese appear, sand-flies abound, currants ripen, &c. Early in September frosty nights may be expected, insectivorous birds depart, at the middle severe night frosts occur, and woodland leaves turn yellow; at the close of the month most of the migratory birds and water-fowl have gone south. Early in October all leaves fall, and the last migratory fowl disappear; at the 20th small lakes and rivers freeze; at the close some snow remains on the ground, the hare and ermine whiten, &c. At the middle of November winter is fully set in.

A similar list of phenomena is given for 1827 at Carlton House, lat. 52° 51′, long. 106° 13′, on the eastern limit of the Saskatchawan basin, 1100 feet above the sea. It differs greatly in the advance of spring from the place before described, and the value of these references in defining the climate of the great area of the northwest renders it desirable to make some extracts from these notes here.

Feb. 15th. Snow thawing in the sunshine; 17th, many sandy hummocks on the plains were bare. This is 3 weeks earlier than an early season at Cumberland House, which is a degree further north, and 200 feet lower.

March 6th. Trees thawed in fine days; 8th, black earth on the river bank softened two inches in depth by the sun. "*At this place westerly winds bring mild weather*, and the easterly ones are attended by fog and snow. 13th, sparrow-hawks arrived from the south; 17th, several migratory small birds were noticed; 29th, large flocks of snow birds; 31st, steep banks exposed to the south clear of snow."

April 1st. Many birds of the sparrow tribe (*Fringillidæ*) were seen; 2d, swans arrived; 3d, much snow gone from the plains; 4th, snow melting in the shade, and sap of the maple tree (*Negundo fraxinifolium*) beginning to flow; 6th, geese arrived; stormy weather about the middle of the month retarded the arrival of the summer birds, but the plants continued to grow fast: 22d, many insectivorous birds; flowers of *Anemone* patens: 27th, ice in the Saskatchawan gave way, frogs heard; 28th, Canada cranes (*Grus Canadensis*) arrived.

May 1. Snow birds disappear; 2d, most of the waterfowl arrived; 4th, *Phlox hoodii* in flower; 5th, various carices in flower, *viola* and *ranunculus*; 6th, many gulls arrived; 7th, sap of the ash-leaved maple ceased to run, and the sugar harvest closed; *populus tremuloides* in flower: 9th, crow blackbirds first seen; 14th, gooseberry bushes coming into leaf; ash-leaved maplo flowering, seven days after the sap ceased to flow, &c.

"The average antecedence of spring phenomena at Carlton House to their occurrence at Cumberland House is between a fortnight and three weeks. The difference of latitude, which is only one degree, is nearly counterbalanced by 200 feet of greater altitude; but the dry sandy soil of the plains, which are early denuded of snow, gives the spring there a great superiority over that of the lower country where the ground is almost submerged, and the greater part of it ice-bound a month after the river is open."

Progress of the Seasons at Cumberland House; Lat. 53° 57′, *long.* 102° 20′, *altitude* 900 *feet.* By Dr. Richardson in 1820, and Chief Factor John Lee Lewis in 1839–40.

March 4th–7th. Water in pools, and much bare ground visible in 1840: 8th–12th, in 1820 a heavy body of snow, first moistened by the sun: 21st, patches of bare ground visible in 1820, 14 days later than in 1840.

April 2d. Saskatchawan river frozen again (1820). 7th, barking crows in 1820, (in 1840 on the 19th.) 10th, willow catkins opening; 12th geese and swans in 1820, but in 1840 they were not seen till the 20th; 17th, plovers and orioles seen; 18th, Canadian jays and fly-catchers; frogs heard; 26th, "the sugar harvest, which is collected in this district from the *Negundo fraxinifolium* (ash-leaved maple) commenced on the 20th of this month, and lasted until the 10th of May." April 28th the Saskatchawan thoroughly broken up, though the ice on Pine Island Lake did not disappear until nearly a month afterward; 30th, *commenced plowing* in 1840.

May 1st. *Anemone patens* (naked wind flower) in blossom, its leaves not yet open, (1820.) 2d. A fall of snow to the depth of two feet, (1840.) 13th. Planting potatoes. 14th. Sowing barley, (1820.) 17th. Willows, gooseberries and aspens in leaf, (1820)—trees bursting their buds (1840) Wheat sown on the 8th (in 1840) above ground, having germinated in nine days. 21st. Barley sown on 14th above ground. 22d. Leaves of trees expanding rapidly; 23d to 30th, in 1840, temperature in the shade at 2 p. m. varied from 78° to 93° Fahrenheit. 30th. Potatoes appeared above ground, planted on 13th (1840.)

June 12*th*. All the forest trees in full leaf.

August 1*st*. Commenced reaping barley. On the 15th, 18th, 19th, and Sept. 1st, the thermometer at noon ranged from 80° to 90°, being the hottest weather of the month. Much thunder and hail on those days, (1839.)

September 2*d*. Flocks of water fowl begin to arrive from the north—3d, first fall of snow; 11th, first hoar frost, birch and aspen leaves turn yellow. 21st. Very heavy snow; 24th, thunder and lightning.

October 1*st*. Taking up potatoes; 5th, leaves all fallen from deciduous trees; 14th, waterfowl going south in large flocks, 1839. 15th, Bays of the lake frozen over; 16th, ground frozen hard; 17th, last waterfowl. In 1839 the Little River was frozen over on the 24th of this month, but broke up again in part, and remained partially open all the winter.

Richardson says that "tropical temperatures occur in the Saskatchawan for a day or two, or it may be for only a few hours at a time in summer, yet the three summer months seldom pass without night frosts. These destroy tender plants, and in untoward seasons injure the growth of cerealia. Wheat, however, ripens well in the drier limestone districts, and still better in the prairie country. Maize ripens well at the Red River and Carlton House and I believe at Cumberland House also."

At Fort Franklin, Great Bear Lake, and near the Arctic Circle (lat. 65° 14′, long. 123° 12′) the seasons differ less than would be supposed from those at the first place named, between Lake Superior and Hudson's Bay, and the effect of greater proximity to the Pacific coast is very decided. The snow is here deepest in March, and at the beginning of April trees begin to thaw; at the 10th snow begins to thaw in the sunshine and insects (*Poduræ*) appear in it; at the end of the month ptarmigan assume their summer plumage. May 1st to 6th waterfowl arrive; singing birds and orioles at the middle of this month; towards the end of May the birch and willow open their catkins and foliage. Early in June several anemones are in flower, frogs are most abundant, and "at the middle of the month summer may be considered as fairly established." Strawberries ripen at July 18th, and all other northern berries soon after. At the last of August the geese fly southward, snow falls, and by September 10th leaves of deciduous trees begin to fall; by the 18th nearly all the migratory birds have left. The frost sets in severely before the end of September; small lakes are frozen by October 10th and the last waterfowl depart; by the 20th winter is fully established.

At this point the period between the first appearance of vegetation and the fall of leaves from deciduous trees is one hundred days, which is the full length of time preventing the growth of plants. This embraces 77 days of summer, ending with August, and 23 of spring, beginning near the 21st of May. The spring has been reckoned earlier than any appearance of leafing in the foregoing classification, and from the commencement of the circulation of sap and vivification of vegetable forms in any manner, which brings it to the 6th of May.

Progress of the Seasons at Fort William, Lake Superior (north shore, Lat 48° 23′, Long. 89° 22′), 1840.

March. At the close of the month hawks and crows appeared, with other migratory birds.

April 2*d*. The sap of the sugar maple began to run; 9th, first wild ducks; 10th gulls, butterflies; 20th general thaw commences—ground frozen to the depth of 3 feet 9 inches; 21st wild geese—30th river partially open.

May 2d. River free of ice; bay of the lake full of drift ice; 8th, mosquitoes seen; 10th, the birch and maple budding.

June 15th. Swallows building in the outhouses.

July 15th. Barley just coming into ear; potatoes in flower; raspberries ripening.

August 8th. Red currants and blue-berries (*vaccinium*) perfectly ripe; 19th, barley ripening; 31st, swallows have disappeared.

September 7th. Leaves of the birch and aspen change color; 13th, vegetables cut down by frost; 16th to 23d, ducks and geese going southward.

October 7th. Leaves of birch and aspen falling; thunder on 6th, 14th and 20th; 14th to 20th ducks, geese, plovers, snipes and orioles abundant in the neighborhood; 31st, snow birds appear.

November 3d. Small lakes frozen over; 9th, river frozen.

December 1st. Ice driving about the lake; 17th, the bay frozen across to the Welcome Islands.
——The close of the season of 1840 was unusually mild.

Progress of the Seasons at Fort Vancouver, Oregon, in 1838. By G. B. Roberts, of the Hudson's Bay Company—(Richardson.)

January 2d. Short young grass affording good pasturage for sheep in places that were flooded in summer; 8th, wild cherry, black currant, and other berry-bearing shrubs budding—ducks, geese, &c., abundant. 10th—12th snow, and vegetation suspended till the middle of February.

February 17th. Wild gooseberry bushes budding; 26th, thunder and hail.

March 1st to *16th.* Thunder and hail showers; 16th, currant in blossom; 21st, apple and pear trees budding, wild gooseberry in full leaf; 24th, first swallows; 30th, humming birds, strawberries in flower.

April 5th. Peach trees in bloom; potatoes coming up; 11th, dogwood and elder in blossom; 17th, several species of violet in flower; 23d brambles in flower; 25th, clover in bloom; 26th, hail and thunder storms; 28th, blossoms of fruit trees falling.

May 1st. Lupines in flower; 7th, wild rose and eglantine in flower; 12th, strawberries ripe; 28th, field peas in blossom; 30th, garden peas brought to table.

June 1st. Spring barley in ear; 5th, new potatoes fit for use; 10th, oats and spring wheat in ear; 23d, gooseberries, currants, and raspberries ripe.

July 19th. Barley ripe; 22d, winter wheat ripe.

August 3d. Oats ripe; 10th, rains begin; 12th, salmon season ends; 27th, mosquitoes abundant;—geese returning from the north.

Sept. 12th. Buckwheat harvested; 19th, barley cut which was sowed 19th of June; 22d, second crop of peas ripe.

Oct. 27th. Columbia river very low.

November 8th. Potatoes killed by frost; 18th, drift ice in the river; 20th, rain and sleet.

December 26th. Snow two inches deep, and less than usual.

The following citation in regard to the climate of Penetanguishene, on Lake Huron, will very well represent all the Canadas, except near Lake Erie, to a point some distance below Montreal. It is also from Richardson's work, and the observations are by Surgeon Todd, R. N.

Phenomena Illustrative of the Climate of Penetanguishene, on Lake Huron.

The spring sets in very suddenly; snow continues until the latter end of April, and longer in the forests than in the cleared lands. March is clear; toward the end of the month the sap of the maple flows; flocks of Canada geese and ducks appear.

Alders and willows flower about the middle of April; ice disappears on the 24th.

The forest trees come all into leaf at the 16th of May; potatoes are planted from 1st to 20th May; cucumbers and melons at the 25th to the end of the month; many wild plants bloom in the woodlands; *viola*, and *xylosteum*, *leontice*, *hepatica*, *erythronium*, &c.

In *June* there are high midday heats, and heavy dews at night.

In *July* and *August* the weather is usually warm and sultry;—towards the middle of August melons ripen, and the wheat and oat harvest begins.

In *September* maize ripens, near the first of the month; at the middle frost destroys corn and vines; forests change their hue; potatoes are dug, &c.

In *October* the forest assumes autumnal hues at the first of the month; at the middle geese and ducks go southward, and the woods are stripped of leaves; snow falls.

In *November* there are "about three weeks of peculiar weather called Indian Summer." In *December* the thermometer sinks a few degrees below zero, and much snow falls; the harbor freezes at the beginning of the month.

In all the States north of New York city and east of Ohio the principal facts may be grouped as follows :—

December, *January*, and *February*, are full winter months ; the exceptions being an irregular occurrence of "thaws" in each month, in which some vegetation starts, perhaps, and the sap of the maple flows.

March, is an open month at all places near sea level ; in the interior at 1000 to 1500 feet elevation the first half is of a full winter temperature, and in cold winters the whole month is so ; but usually the sap of the maple flows for the whole month in the lower districts, and for the last half of it for the elevated districts ; with such attendant vegetation as the bursting of willow catkins, the swelling of buds ; appearance of crocus, of flowers of *acer rubrum*, &c. Earliest passage and insectivorous birds appear.

April 1*st* to 15*th*, is too cool for expansion of huds and leaves in the elevated districts, and in these the sap of maple flows unaltered for the first five days, but in the lower districts it is changed at or before the first of the month. Forest flowers become numerous as the buds expand, and the low forest shrubs show leaves. Grass is abundant from the 10th in the lower districts, and from the 20th in the more elevated. Field cultivation begins at the same dates, and wheat is often sown ten days earlier. Insectivorous and singing birds arrive,—30th swallows arrive. April 16th is the mean date of opening of lake and harbor at Buffalo for 28 yrs. 1827—1854 ; April 21st the mean date of opening the Erie Canal for 31 years, 1824—1854. (N. Y. *Meteorological Report*, 1856.)

May 5th. Peach and cherry in bloom in the lower districts, but not till 10th or 15th in the more elevated ; 10th, Indian corn planted, and spring grains sown in the first named districts, with corresponding differences for the second; leaf buds of maple opening ; 15th, various under shrubs of forests in full leaf ; 20th, apple tree in bloom ; 25th, forest in leaf ; 31st, winter wheat, &c., showing heads.

June 5th. Forest in full leaf ; earliest clover in blossom ; frosts are known as late as the 5th to 10th in extreme years. 15th, earliest cherries ripen in the lower districts, at 25th in the more elevated.

July 5th. Earliest appearance of male flowers, or tassel, of Indian corn, heads of grasses (*phleum*) appear ; cherries ripen, with the *amelanchier.* 10th hay harvest commences ; 15th wheat harvest commences ; 20th earliest apples ripen.

August 1*st.* Indian corn first fit for cooking ; apricots ripen ; 20th earliest peaches.

September 1*st.* Early peaches ; 10th Indian corn ripened ; 15th first light frosts ; 20th forest leaves begin to change color ; 30th severe frosts, first forest leaves falling ; vegetation liable to injury by frosts closed.

October 15*th.* Return of passenger birds ; forest leaves falling profusely ; 30th snows ; last forest leaves fallen.

November 20*th.* Close of navigation of the lesser canals and interior rivers ; snows remaining irregularly.

December 18*th.* Close of navigation of Hudson at Albany ;* 10th complete establishment of winter in the country generally, which is ten days earlier in the upland districts. Dec. 7th is the mean date of close of navigation on the Erie canal for 31 years, 1824—1854. (Met. Rep. N. Y., 1856.)

At Philadelphia all these phenomena are eight to fifteen days earlier in spring, and fifteen to ten days later in Autumn, with a similar succession ; the earliest in spring and latest in autumn differing less from the averages here given for the latitude of Boston and Rochester than those belonging to the warmer months.

In the following table some average dates for the principal phenomena of the advance of the season, which have been observed for a sufficient period, are given from various sources. The extreme irregularity of these south of Virginia, or of such as relate to the spring advance of vegetation, at least, renders the accumulation of statistics of little use there. The same phenomena may be developed by a few warm days at an early period, and afterward suffer weeks of suspension, perhaps to reappear a second time in such a manner as to wholly destroy the fruit. For the districts north of Baltimore, however, the averages for the same locality or vicinity, and of various dates, agree very closely.

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* Mean date derived from sixty-five years record at Albany, 1789 to 1854. *Regents Reports.* Mean date of opening of navigation on Lake Erie at Cleveland, March 23d. (10 years.)

Mean Date of some Constant Phenomena of the Seasons.

				Blossoms.		Harvest.	Frosts.	
				Peach.	Apple.	Wheat.	Spring.	Autumn.
Oxford Co., Me.	*Wadsworth.*	31 yrs.	1817–1848	..	..	..	..	Sep. 15
Roxbury, Mass.	*Lowell.*	17 "	1815–1833	May 2	May 16	..	..	..
Cambridge, Mass.	*Bond*, &c.	19 "	1834–1855	May 5	May 15	..	..	..
Waltham, Mass.	*Fisk.*	32 "	1807–1838	..	..	..	..	Oct. 2[1]
Mansfield, Mass.	*Stearns.*	22 "	1834–1855	..	..	..	..	Sep. 23[2]
(Do.)	(Do.)	10 "	1798–1807	..	May 21	..	..	..
(Do.)	(Do.)	10 "	1808–1817	..	May 23	..	..	..
(Do.)	(Do.)	10 "	1818–1827	..	May 20	..	..	..
(Do.)	(Do.)	10 "	1828–1837	..	May 20	..	..	..
(Do.)	(Do.)	40 "	1798–1837	..	May 21	..	..	..
Worcester, Mass.	(Hospital.)	8 "	1839–1846	May 3	May 11	..	..	..
Providence, R. I.		6 "	1831–1836	May 8	..	..	..	..
E. Hampton, Long Is'd.	(Academy.)	15 "	..	..	..	..	..	Oct. 23
Flatbush, Long Is'd, N. Y.	(Acad.)	24 "	1825–1849	..	..	..	..	Oct. 4
North Salem, N. Y.	*Jenkins.*	10 "	1840–1849	Apl. 27	May 3	July 12	May 21	Sep. 25
Albany, N. Y.	(Acad.)	22 "	1825–1849	..	..	..	..	Oct. 7
Utica, N. Y.	(Acad.)	22 "	1825–1849	..	..	..	..	Oct. 4
Gouverneur, N. Y.	(Acad.)	12 "	..	..	..	..	..	Sep. 12
Hamilton, (1127 ft.) N. Y.	(Acad.)	15 "	..	..	..	..	..	Sep. 11
Rochester, N. Y.	*Dewey.*	7 "	1847–1853	May 11	May 20	July 12	..	Sep. 26
Auburn, N. Y.	(Acad.)	20 "	1826–1849	..	..	..	..	Oct. 1
Lewiston, N. Y.	(Acad.)	17 "	1826–1849	..	..	..	..	Sep. 22
Fredonia, N. Y.	(Acad.)	16 "	1826–1849	..	..	..	..	Sep. 28
Seneca Co., N. Y.	*Delafield.*	28 "	1822–1850	..	..	July 15	..	..
Oxford, N. Y.	(Acad.)	16 "	1826–1849	..	..	..	..	Sep. 16
Cortland, N. Y. (1096 ft)	(Acad.)	17 "	..	..	..	..	..	Sep. 14
Prattsburg, N. Y. (1494 ft.)	(Acad.)	10 "	..	..	..	..	..	Sep. 26
Perth Amboy, N. J.	*Parker.*	13 "	1819–1831	Apl. 21	May 2	..	..	..
Lambertville, N. J.	*Parsons.*	13 "	1840–1855	Apl. 14	Apl. 26	..	May 17	Sep. 23
Baltimore, Md.	(— *Alm.*)	9 "	..	Apl. 13	Apl. 30	..	..	..
King George Co., Va.	*Tayloe.*	5 "	1831–1835	..	..	..	Apl. 20	Oct. 6
Richmond, (35 m. N. of) Va.	(— *Alm.*)	4 "	..	Mch. 10	Mch. 25	..	..	..
Chapel Hill, N. C.	*Phillips.*	4 "	1850–1855	Mch. 8	Mch. 31	..	..	..
Charleston, S. C.	(Ft. Moultrie.)	5 "	1850–1854	..	..	..	..	Nov. 6
New Orleans, La.	(Mil. Post.)	5 "	1849–1853	..	..	..	..	Nov. 16
Baton Rouge, La.	(Mil. Post.)	6 "	1849–1854	..	..	..	..	Oct. 24
Natchez, Miss.	*Dunbar.*	11 "	1798–1808	..	..	..	Apr. 6	Oct. 21
(Do.)	*Affleck.*	26 "	1825–1850	..	..	..	Mch. 22	Nov. 9[3]
(Do.)	*Tooley.*	4 "	— -1855	Feb. 10	Mch. 25	..	..	..
St. Louis.[4]	*Engelmann.*	20 "	1824–1853	Apl. 9	..	..	Apl. 6	Oct. 26
Near Cincinnati.	*Jackson.*	35 "	1814–1848	Apl. 11	..	..	May 6	Oct. 3
Summit Co., Ohio.	*Wadsworth.*	32 "	1822–30; 34–56	Apl. 26	..	..	..	..
Madison, Wisc.	(Alm.)	4 "	1848–1851	..	May 8	..	..	..
Muscatine, Iowa.	*Parvin.*	7 "	1850–1856	May 1	May 3	..	May 6	Sep. 24

[1] "Destructive to vegetation,"—mean of observed temperatures 30°.

[2] Severe frosts; mean of observed temperatures 27°.

[3] The *extreme* dates for the "latest frost of Spring" are Feb. 16 and April 15; of the "earliest fo autumn" Oct. 19 and Nov. 30. The mean date of first flowering of cotton at Natchez for eleven years was June 4; the extremes May 17 and June 24. The absolute destruction of cotton by frost was somewhat later than the date of first frosts, and for ten years, 1841 to 1850, the earliest destruction of cotton was on October 19th. In 1849, there was no destructive frost before the close of December. (*Affleck.*)

[4] These will not compare with other positions, since they are instances of the thermometer falling to 32° within the limits of the city. (*St. Louis Med. and Surg. Jour.* 1852.)

Those from Academies in New York are from a valuable table prepared from the Academy reports by Dr. Hough, in the quarto volume of results of Meteorological Observations at the New York Academies. The average and extreme dates of the earliest frost and earliest snow are there given from fifty-five stations; the extremes of which are Sept. 11 in the northern part of the State, and Oct. 23 on Long Island for the first frost; and Oct. 15 and Dec. 3 for the first snows, the same positions being taken.

DAILY CURVE OF ATMOSPHERIC WEIGHT, OR HORARY VARIATION OF THE BAROMETER.

The daily change of atmospheric weight in a curve through the successive hours of the day is of practical importance in barometric determination of heights in all middle latitudes, but beyond this it is mainly of philosophical interest. There are two daily tides, which are very regular and nearly equal in the tropics, forming a curve of two maxima, of which the first, occurring at 9 or 10 a. m., is a little the largest, and the second follows at nearly twelve hours distance. In the temperate latitudes the morn-

ing elevation remains nearly the same, but the evening tide becomes very small, and in the higher latitudes both disappear. Richardson found no appearance of any variation at his winter stations on Great Bear Lake, where seven months of very accurate observations were made at Fort Confidence, latitude 66° 54′.* The observations previously made in high latitudes were at sea or on the Arctic coasts, and this series may be regarded as decisive that these daily tides do not go so far north as the Arctic circle either on the continents or at sea.

Another point of importance in the distribution of this phenomenon is the change of position among the hours in the high and arid regions of the interior of this continent, at latitude 30° to 45° north. It is there later in reaching the maximum point of the curve ; at five thousand feet above the sea, in New Mexico, nearly at 11 o'clock, instead of at 9 in the morning, as at the Atlantic coast in the same latitudes. At greater elevations it is still later, and on the summits of the Alps it goes so far as to occupy with the principal maximum the place of the principal minimum at sea level; the greater, and in fact the only maximum, occurring at 3 to 4 p. m., which are the hours of the lowest barometer at sea level.† The definition of this variable position is far from being complete, as in most cases a few observations only could be made at these elevated points, and the averages of a continued series are yet necessary to determine what the law of change is. The approximate curves we now have are still of practical value in barometric calculation, and they may lead to more accurate observation at similar occasions in future.

The representative curves, Plate XIII, may be given for the various districts from the best observations at hand, as in the former case, and the diagrams explain the observations given in the following table.

Kaemtz remarks that Daniell was the first to observe that the barometer on St. Bernard was higher in the afternoon than in the morning, while the contrary was the case at Geneva. He gives observations by Eschmann on the Riga, and Horner at Zurich, with his own on the Riga and Faulhorn, which establish the same form of the curve. Upon these observations a discussion of the principles of the variation is based, and an elaborate formula constructed, which Martins examines and shows to be inapplicable to the requirements of the whole case. Martins combines the best five series of observations on the Faulhorn, and obtains a scale which he regards as nearly accurate; it has a prolonged maximum from 12 o'clock noon, to 10 p. m., and a minimum branch equally prolonged from midnight to 10 a. m. Four of the series used by him "agree with each other, and establish the existence of a maximum about 10 p. m., and a minimum about 6 a. m. ; it appears also that the maximum of 10 a. m. has receded to 3 p. m. and the minimum which follows it near 5 p. m. is very slight, the slightest disturbance being sufficient to cause this depression or retrograde movement to disappear."

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* Magnetic and Meteorological Observations at Lake Athabasca and Fort Confidence, 1855.

† Prof. J. D. Forbes generalizes upon this horary curve of pressure, (in the Transactions of the Royal Society, and in Brewster's Edinburgh Journal of Science for 1831–2, p. 209,)—and says, "the St. Bernard's observations demonstrate, by the annual results for five years, 1826 to 1830, that the barometer is there, at 8000 feet elevation, *lowest* at 9 a. m. and *highest* at 3 p. m. ; precisely the reverse of what has hitherto been supposed." Prof. Forbes also asserts that Captain Parry's observations at latitude 74° north show the existence of all the oscillations of lower latitudes, including that at 4 a. m. which is rare, but *reversing the points of maximum and minimum* again, as on the higher Alps. He cites six months' observations at Port Famine, Straits of Magellan, lat. 53° 38′ south, by Captain King, which show the readings at 3 p. m. to exceed those at 9 a. m. by .0207 inch ; a result similar to that at the Arctic regions observed by Captain Parry.

Kaemtz compares the amount of fluctuation at different altitudes, and infers its entire disappearance at no great elevation above the highest observed point of the Alps. Here we find it greatest at elevated points, probably because the surface facilitates excessive local heating, and thus increases the discrepancy of day and night temperatures in the volume of air lying over it. Obviously neither formula proposed by Kaemtz or Martins will apply to the conditions in the American interior, and the scales of horary correction must be drawn from actual observation at every important altitude and district.*

The reduced measure of oscillations in the colder months is pointed out by the same author, and a table of differences for the several months is given at Halle and Milan. This difference is practically of little importance, though it corroborates the view that the whole oscillation is simply due to the daily change of temperature. Where the temperature changes are excessive, we may anticipate the greatest change of pressure, as a consequence, for any latitude, and the great range in New Mexico, where the daily variation of temperature is very great, still further establishes the relation. There are now observations in sufficient abundance in continental positions to show the principal facts of importance, and to permit the application of the deductions to all the practical uses of barometric engineering, when the Russian observatory results became fully accessible.

Hourly Variations of the Barometer at the Principal Stations.

Hours.	Fort Confidence.	Sitka, lat. 57° N	Toronto, 6 yrs. h'rly.	Cambridge.	Philadelphia.	Washington.	Albuquerque	Greenwich.	St. Petersburg.	Frontera.[1]
1 a. m.	..	29.834	29.615	..	29.938	..	..	29.778	29.986	26.439
2 "	..	29.832	29 615	..	29.936	30.018	..	29.773	29.984	26.437
3 "	..	29.833	29.615	..	29.933	..	..	29.770	29.982	26.438
4 "	..	29.834	29.616	..	29.935	30.019	..	29.768	29.981	26.436
5 "	..	29.834	29 621	..	29.941	..	..	29.768	29 981	26.439
6 "	29.033	29.831	29 631	29.944	29.951	30.033	25.170	29.771	29.981	26.437
7 "	29.046	29.830	29.639	..	29 960	..	25.187	29.777	29.982	26.443
8 "	29.045	29.832	29.646	..	29 966	30.049	25.201	29.783	29.984	26.459
9 "	29.046	29.833	29.648	29.951	29.969	..	25.212	29.789	29.985	26.487
10 "	29.042	29.835	29.648	..	29.967	30 056	25.218	29.792	29.991	26.473
11 "	29.051	29 838	29.641	..	29.958	..	25.220	29.791	29.991	26.511
12 m.	29.052	29.841	29.629	..	29.944	30.028	25 197	29.786	29.991	26.510
1 p. m.	29.045	29.841	29.618	..	29 927	..	25.160	29.781	29.989	26.468
2 "	29.046	29.840	29.608	..	29.916	30.001	25.130	29.776	29 988	26.432
3 "	29.052	29.838	29 605	29.903	29.910	..	25.119	29.774	29.984	26.410
4 "	29.049	29.838	29.603	..	29 909	29.990	25.110	29.772	29.983	26.396
5 "	29.047	29.837	29.604	..	29.911	..	25.115	29.771	29.982	26.395
6 "	29.047	29.838	29.608	..	29.918	29.994	25.125	29.774	29 981	26.396
7 "	29.040	29.835	29.611	..	29.927	..	25.135	29.780	29.982	26.401
8 "	29.050	29.835	29.616	..	29 935	30.012	25.150	29.785	29.983	26.420
9 "	29.041	29.835	29.620	29.934	29.943	..	25.160	29 788	29 985	26.437
10 "	29.157 ?	29 835	29.620	..	29.946	30.022	..	29.790	29.986	26.452
11 "	..	29.837	29 620	..	29 949	..	..	29.789	29.986	26.462
12 "	..	29.836	29.616	..	29.941	30.020	..	29.785	29 987	26.466
Mean	29.046	29.835	29.621	29.930	29.935	30.020	25.160	29.780	29.985	26.443

1 Communicated by Major Emory, Commissioner, to the American Association for the Advancement of Science.

* The same result in one respect, that of being still decided at great altitudes, appears in India according to Lt. Col. Sykes' discussion of meteorological observations there, though that also differs from the American form in occurring nearly at the hours observed at sea level. "Lieut. R. Strachey found the horary oscillations of barometer at an elevation of 18,400, 16,000, and 11,500 feet were as regular as on the plains of Hindostan, and the hours of maxima and minima were the same." This was on the Lunjar mountains in Thibet, at 31° 2′ north latitude. At Dodabetta, 8640 feet above the sea, the range of the oscillation was .06 (six-hundredths of an inch) and the extreme hours 9h. 40m. a. m. and 3h. 40m. p. m. At this point "the most violent storms do not affect the range—ten inches of rain, and two days of violent and variable wind on 17th and 18th of April, 1847, did not affect it." (Phil. Trans. 1850.)

The curves for the middle latitudes are everywhere similar, having two unequal branches placed at nearly the same hours in each case, and only at the interior stations show any contrast of importance. In this interior here the curve at Albuquerque presents the type of all those so far observed ; at El Paso a series of a month or more of observations at frequent hours, and for seven days at 15 minutes interval by the officers of the Boundary Commission, exhibits the same peculiarities, and another by the officers of the Pacific Railroad Survey at the 35th parallel for a few days at Zuñi, a still more elevated station west of Albuquerque. That at Zuñi has its morning maximum at 11 a. m., as in the curve given here, and all the results, partial and complete, give the same indications for the arid and elevated interior.

The postponement of the greatest daily pressure to later hours in elevated districts has been observed at various points on the Alps, and empirical scales of reduction have been applied for different altitudes to render the observations comparable with those at the base of the mountains, or at sea level; or equivalent to the simultaneous observations necessary in determining differences of altitude.

Though simultaneous in time, a discrepancy is introduced by the varying position of the daily curve, and the fact of discrepancy is shown both by the changes in the pressure at the higher point as absolute quantities, and by the variable measures of height derived from the comparison of observations. The same observer obtains values differing largely at different hours for the elevation of points measured barometrically on the Alps, and different observers arriving at a point at different hours find their observations not to agree. Above 10,000 feet of elevation there is much uncertainty in regard to the daily tides, and there is probably but one oscillation ; and above 8000 feet the position of the daily maxima and minima is nearly or quite reversed.

It is not proposed to open the difficult questions relating to the theory of this daily oscillation of pressure, but if due, as it appears to be, simply to the daily heat of the sun and the rarefaction it causes, the extension of the curves, or their prolongation to later hours at great elevations, is not difficult of explanation. A greater absolute quantity of air is lifted above any such elevated point as the rarefaction proceeds, and though the pressure at sea level is greatest while the expansion is in progress, it is greatest at elevated points after it is completed, and after the greater mass of air is lifted above the point. This must occur after the increase of heat has ceased, and at or after the warmest hours. It may be still greater when the cooling of the mass is most rapid and the upper rarefied volumes are falling to lower levels ; or it may, for some little time then, be equal to the pressure when the greatest quantity of air is above the line or the point observed. The double curve of the tropics, and the absence of oscillations or reversal of position at the borders of the arctic regions, present peculiarities not solved by this hypothesis, perhaps, but the facts of change of hours and position at different altitudes in the middle latitudes are a strong support of the view that the daily heat and rarefaction originate all the phenomena.

The efforts of the first observers of this peculiar curve of pressure to correct the discrepancies it originates may throw some further light on the point, and its relations to barometric engineering render it one of the most important applications of the law of horary variation of atmospheric pressure. It is impossible to clear it of all its difficulties, however, or to render the statement and illustration complete in the present state of observation and experiment upon it.

A recent discussion of the application of this variable horary state to barometric measurement in the Alps is given by Bravais,* with a scale of corrections for certain

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Humboldt in the Cosmos says "I have found the regularity of the ebb and flow of the aerial ocean undisturbed by storms, hurricanes, rain and earthquakes in the torrid zones of the new continents, on the coasts, and at an elevation of 13,000 feet."

* Comptes Rendus, July to Dec., 1850, p. 175 ; in a letter to M. Mathiew.

hours of the day applicable to the Rigi, Faulhorn, and Plateau of Mont Blanc, as deduced from his own observations combined with those of Kaemtz and Martins. It is as follows :—

at 12 m.	subtract	1-97th of the altitude.		at 4 p. m.	subtract	1-173	of the altitude.
" 1 p. m.	"	1-95	" "	" 5 p. m.	"	1-300	" "
" 2 p. m.	"	1-103	" "	" 6 p. m.	"	1-1000	" "
" 3 p. m.	"	1-125	" "				

The position of the points of this scale differ so widely from that of the points of maximum and minimum pressure at lower levels, that it must obviously belong to a specific altitude, yet specific altitudes are not mentioned. It can only belong to great altitudes, and from other remarks of Bravais in the same connection, it doubtless applies to the particular altitude of the Grand Plateau of Mont Blanc, more nearly than to any other, or to an altitude in the Alps of 13,000 feet.

These comparisons are with Paris, and they are also equivalent to those with the sea level ; and the corrections thus obtained would apply to observations by a solitary observer who deduces his altitudes by comparison with mean readings for the latitude. M. Bravais also gives a list of altitudes deduced from comparison of barometers at Geneva and on the Grand Plateau, showing considerable differences at different hours, and rendering it clear that simultaneous observations at localities differing so largely in altitude are quite inadequate to precise determination. As an illustration of these differences he gives the following results :—

Comparison of Simultaneous Readings of the Barometer at the Grand Plateau and at Geneva.

At 12 m.	give	3521.6	metres difference.	At 10 p. m.	give	3468.7	metres difference.
" 2 p. m.	"	3526.0	" "	" 12 p. m.	"	3452.6	" "
" 4 p. m.	"	3507.2	" "	" 6 a. m.	"	3456.2	" "
" 6 p. m.	"	3493.0	" "	" 8 a. m.	"	3493.2	" "
" 8 p. m.	"	3480.7	" "	" 10 a. m.	"	3512.6	" "

Another series gives similar results. Obviously a source of error sufficiently great exists to require a considerable number of empirical tables in attaining accuracy where the altitudes and points of comparison are various, as in case a line were carried over Mont Blanc, and the altitudes of various portions of it were determined by simultaneous comparisons with Geneva, Chamouni, or any intermediate station, and other points were referred to the level of the sea. As these variable scales of correction are shown to be absolutely required for accurate results, we find the apparently simple constant of horary variation rising into a most complicated element, and practically to be a variable source of error indeed,—since a line from Paris to Geneva, and ascending Mont Blanc to descend into Italian valleys ultimately, would require at least three different scales of correction for horary variation alone.

Bravais gives another empirical table copied from *Horner*, in which the hours and altitudes are sought to be arranged in solution of the variability of this constant in position. It is not mentioned whether it belongs to direct comparisons with sea level alone or not ; but it obviously does not vary sufficiently in the position of its positive and negative quantities with the changes of altitude, if the previous measures are correct.

Heights in Toises,—correction applied.

	12 m.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.
At 200 Toises	—0.6	—0.4	—0.3	—0.1	+0.1	+0.3	+0.5
" 400 "	—1.4	—1.1	—0.7	—0 5	+0 1	+0.6	+1.1
" 600 "	—2.4	—1.8	—1.3	—0.4	+0.2	+1.1	+2.0
" 800 "	—3.7	—2.8	—2.0	—0.6	+0.3	+1.7	+3.1
"1000 "	—5.2	—4.0	—2.8	—0.8	+0.5	+2.3	+4.4
"1200 "	—7.0	—5.4	—3.7	—1.1	+0.7	+3.2	+5.8

These tables at least show the importance of the new correction for horary variation of pressure, and that the position of the curve in the day, as well as the measure or quantity of the correction, varies largely with the altitude. Horner's table has a range of 42 feet above, and 35 feet below the true position for the hours here given, and probably a maximum range of 100 feet between the extreme hours. In the other tables the difference is still greater,—between Geneva and the Grand Plateau amounting to 148.5 feet in the extreme range. These are quantities sufficiently important to repay the most thorough analysis of their laws.

The lines of the recent American surveys traverse extensive districts lying wholly above even the snow line of the Alps, as well as chains of mountains whose lowest passes are above the Mer de Glace. All the problems of this horary variation of pressure occur in the ascents and descents of such districts, and in the measurement of the altitude of every part and point by the barometer alone. The single comparison of Santa Fé with the sea, or of Coochatope Pass with Santa Fé, Fort Massachusetts, or the sea, which would be analogous to the comparisons quoted from Bravais, would present but a small portion of the difficulties of this single correction.

At Albuquerque, New Mexico, an altitude of 5000 feet, Lieutenant Whipple found the greatest pressure at 11 a. m., and the least near 5 p. m.; the first point being thrown forward fully two hours, and the last nearly as much. An approximate scale of measures of the barometer, corrected for temperature, in excess or deficiency at the several hours was prepared by the author for use here, as follows:

6 a. m.	+.010 inches.	1 p. m.	—.009 inches.
7 a. m.	+.030 "	2 p. m.	—.030 "
8 a. m.	+.045 "	3 p. m.	—.040 "
9 a. m.	+.050 "	4 p. m.	—.050 "
10 a. m.	+.057 "	5 p. m.	—.045 "
11 a. m.	+.070 "	6 p. m.	—.035 "
12 a. m.	+.032 "	7 p. m.	—.025 "

The peculiarities of this curve are a slow and sustained increase of pressure from 8 to 11 a. m., instead of the more rounded form this maximum takes in lower districts, and a very abrupt fall from the maximum to the minimum. The greater measure of the variation than that found at or near the sea level is also remarked. Observations at other localities in this elevated and arid region confirm both these features, and show the corresponding correction to be quite indispensable to accurate measurement of altitudes there. At Zuni, a still more elevated locality, 6350 feet above the sea, the few observations made indicate a corresponding extension of the hour of maximum pressure forward, though they are too few in number to give the positive measures of a scale.

This brief discussion of the correction having its basis in horary variations of atmospheric weight, is sufficient to show that it must be added to the list of elements of computation, to attain any satisfactory degree of positive or relative precision. Especially where grades are determined by differences of altitude between places measured at successive hours, as in a day's passage of a mountain pass, it becomes of great practical importance that this error should be corrected.

The extended analysis necessary to fully illustrate the remaining corrections required in practical use of the barometer renders a separate paper necessary for each. The non-periodic variations of pressure are practically the most important, and errors from this source the most difficult to avoid. But this is not a correction for which a scale of definite values may be employed, yielding, in this respect, to another resulting from the unequally heated lower atmosphere, and the consequent inadequacy of the air temperatures observed to represent the entire mass. The correction deduced from these air temperatures is therefore erroneous,—too great, or too little, as the observed temperatures exceed or fall below the true measure of the air temperature as a mean of its mass, or as reduced to a uniformly decreasing quantity throughout the mass.

Where the lower and observed stratum of the atmosphere differs very considerably from the average temperature, as in a glen greatly heated by the sun, or in a valley greatly cooled by radiation, the error from this source is large if the altitude is great. The correction for air temperatures is large at all considerable altitudes, and the necessity for obtaining the proper temperatures increases with the altitude, accordingly. These corrections are interesting as philosophical points in physical science little known, and much more from their practical value in the most gigantic work of determination of altitudes with the barometer ever undertaken—almost the greatest possible to be undertaken. The vertical topography of a continent has never been attempted by parallel lines of exploration on a scale corresponding with the system of Pacific Railroad Surveys, whose observations have disclosed these sources of error, and shown them to be practical questions, and whose determinations have been corrected for them.

Practically the non-periodic variations of pressure belonging to all temperate latitudes are the greatest source of error in barometric calculations, and the most difficult to avoid. The earlier theory was that all observations should be simultaneous, and that the calculations should always be between places directly compared. For vertical ascents or precipitous mountain sides this is not difficult, but for the extended lines of a survey it is quite impossible, and we are thrown upon various expedients for avoidance of error. Mean results of observation for a period of three or more days usually embrace the extremes of this variation in this climate, and as the altitudes increase, *a less period is covered by any single oscillation.* The measure of variation in these non-periodic extremes is also one *decreasing with the altitude.* At 5,000 to 7,000 feet it is rarely one-half its measure at the level of the sea.

The following notes of the history of the barometer, and of its application to various purposes of measurement, are mainly from the Transactions of the Royal Philosophical Society, and they have especial interest in connection with the discussion of the present problems of barometric measurement.

Dr. Beal, in one of the earliest numbers of these Transactions* has a paper "On the Barometer and some observations made with it," in which he speaks with great satisfaction of the new instrument, "founded on the Toricellian experiment," and remarks that it was first made public by Mr. Boyle, and "employed by him and others to discover all the minute variations in the pressure and weight of the air." Dr. Beal "tried several times to alter the air in his closet by fumes and thick smokes, but the mercury seemed not to be affected more than what might be expected by some increase of heat; such as have exact wheel barometers may try whether odors or fumes make the air lighter." Several papers giving directions and observations in regard to the barometer were prepared near this time by Drs. Beal and Wallis, and Mr. Boyle; and Dr. Hook's "marine barometer," which was a compound of an air and spirit thermometer, was much used. Halley has an essay on Hook's and Patrick's barometers, the last of which is a glass tube five feet long inverted in a cistern of mercury. Dr. Scheuchzer gives a thorough essay on the heights corresponding to the different barometric readings, with tables "calculated on the principle of the hyperbola;" his table for the differences of height corresponding to each tenth of an inch in the barometric reading is nearly that of the most recent calculations.

At 31 inches of the barometer,	one-tenth	= 82 feet.				At 28.0 inches of the barom.,	one-tenth	= 91.09 feet.			
30.5 "	"	"	"	= 83.6 "		27.5 "	"	"	"	= 92.74 "	
30. "	"	"	"	= 85. "		27.0 "	"	"	"	= 94.47 "	
29.5 "	"	"	"	= 86.4 "		26.5 "	"	"	"	= 96.25 "	
29. "	"	"	"	= 87.9 "		26 "	"	"	"	= 98.10 "	
28.5 "	"	"	"	= 89.5 "							

* These citations are mainly from Eames and Martyn's Abridgment, 1718 to 1733.

Dr. Nettleton constructed a table from logarithmic elements on the principle that the logarithms of the heights and of the densities are as the elevations, reciprocally, making 30 inches the standard height, and taking 85 feet, empirically, as the difference corresponding to the first tenth of an inch, the successive differences are calculated.

In the Philosophical Transactions for 1774 De Luc's very elaborate formulas and tables are given, translated into English measures by Dr. Horseley. In this is given the original logarithmic curve, and the mathematical principles of the several corrections are discussed at great length. The rules deduced are similar to those now in use for determining differences of altitude,—the difference of the logarithms of the two barometric readings being divided by 1000 for the approximate height in fathoms, and corrections for the differences of barometric and air temperatures being applied.

Prof. Forbes enumerates De Luc, Shuckburg, Playfair, Laplace, and Raymond, as the greater authors of the formulæ of barometric calculation. (Edin. Journ. of Science, 1830–31.) A very compact statement of the steps by which the present perfection of barometric determination of heights was attained is given by De Malortie,* which may be quoted here.

"About 160 years have elapsed since Pascal, having caused Torricelli's barometer to be carried to the top of Puy de Dome, remarked that this instrument presented the means of leveling the most distant places. . . . Newton in his Principia perfected the theory (which Halley had put in the form of a mathematical formula, by which the altitude of two stations may be calculated from the heights of the mercury at each), by showing what regard was to be paid to the diminution of the gravity of the molecules of air at different heights, but he omitted to consider the effects of the variations of heat, and of the progressive decrease of the temperature, on the density of the beds of air. At this time observations of the barometer and thermometer were not even employed in the measurement of astronomical refractions; Bradley, Mayer, and Lacaille began to introduce them about 1750; until then the only method was to use different tables of refraction for summer and winter."

The barometric formula without correction for temperature was very imperfect, and it failed to give accurate results except in a few instances, the irregularities followed no law, also. Though Lambert and other able philosophers and geometers were much occupied with the barometer, the true cause was not discovered until De Luc found the source of the anomalies by comparing the observed temperatures of the air and the corrections found necessary in cases where the heights were known, and by experiments on the comparative expansion of air and mercury. This animated the zeal of barometric observers anew, and Dr. Maskelyne undertook to translate the new formula into English measures. Playfair added the correction for difference of gravity at different latitudes; Sir George Shuckburg verified the results of De Luc, and Gen. Roy measured the height of a great number of places in Great Britain. The Alps were levelled by Saussure and Pictol, the Pyrenees by Raymond, and the Andes by Humboldt.

But the formulas were not yet sufficiently simplified. "De Luc had adapted the constant co-efficients of his formula to a certain temperature which he called *normal*, and which he had fixed from the condition that for this temperature the difference of level became a decimal multiple of the difference of the tabular logarithms of the observed barometric height. All the corrections for temperature changed, therefore, when any other measure than French toises was used.

Laplace, in the *Mécanique Celeste*, determined the whole anew, taking the expansion of air from Gay Lussac's experiments, taking also the humidity into the account, and finally determining the general co-efficient of the formula from barometric observations

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* *A Treatise on Topography*, by C. S. De Malortie, of the Royal Military Academy, Woolwich, 2 vols. 8vo., London, 1815.

themselves; using for this purpose a great number of experiments in the Pyrenees by M. Ramond. The value of this has been determined by Arago and myself* (Biot) in a direct manner, by the compared weights of air and mercury. So that all the elements of the barometric formula, the research of which has cost travellers so much labor, might have been obtained without going out of the laboratory, and with as much accuracy. It still remained to compare barometric tubes accurately, which Laplace has done by capillary tables."

In a *Treatise on Military Surveying* by Lieut. Col. Basil Jackson† there are other valuable references to the principles of barometric survey, and Biot is quoted as follows: "We may now entertain a hope that in a space of some years the general levelings of Europe will be obtained, and we may undertake, agreeably to the idea suggested by Laplace, to add to the latitude and longitude of cities their height above the sea as a third co-ordinate which would completely determine their positions."

The tables of Laplace were simplified still more by Oltmans, whose tables are copied by Guyot in his collection. In all these the formula was combined in a single expression, and the imperfection of some of the corrections left it still liable to error. Col. Jackson cites several conditions under which the determination of height is in excess, and again when it is in deficiency,—different winds, localities, and exposures. Ultimately the elements of the calculation have been separated in the tables of Prof. Loomis, and each may be applied with such emendations as are required for itself, instead of being combined in a general expression. The writer used these elements separately, of necessity, for a considerable time before this reconstruction of the tables was effected, and the corrections for air temperatures, particularly, always required modification and an independent consideration. Jackson (p. 191) remarks that "strictly the law of decrease of temperature in the atmosphere should be known. Generally, at smaller heights, it is a very slow arithmetical progression." Unless it is a regular arithmetical progression it is easy to see that the correction for difference of air temperatures may not attain to accuracy, and that it may be largely in error, indeed. This is particularly the case in measurements compared, as a continuous line of points in a survey must be, with the mean barometric and temperature readings at sea level; the regular progression of decrease belonging to the case assumed as a basis, but having no parallel in the other, because of the presence of strata of air very warm or very cold, yet thin and superficial, and not correct representatives of the average at the observed point.

The correction in Laplace's formula for the difference of temperature of the two barometers is rendered unnecessary by the simple process of reducing both to the equivalent of the freezing point. The corrected tables of the relative expansion of brass and mercury prepared by Shumacher for the Royal Society give the best possible scale of corrections, and assist to rid the primary formula of an element which has no necessary relation to it.

With the elements of the calculation separated in this manner, as in the tables recently prepared by Prof. Loomis, the calculation of altitudes from barometric readings becomes very simple, while retaining as much of accuracy as the case admits. The corrections for air temperatures will remain difficult, from the inherent difficulty of the case, since it is rare that the surface atmosphere presents a mass of air decreasing uniformly in temperature in the ascent on a vertical line. By so much as the observation at the surface fails to represent the actual average, the result will be in error on

* From *Traite de Physique* of M. Biot. Most of the entire statement is in Biot's words.

† London, 1847—8vo.

one side or the other, and averages derived from a considerable number of observations can alone give a correct result.

In a series of balloon ascents at Kew* the temperatures at all points below 24,000 feet were observed with great care, and the whole principle of the case is easily deduced from the diagrams by which those observations were illustrated. In brief the result was that the lower strata often gave no decrease of temperature for 2000 or 3000 feet, while above the line of cloud formation they fell off abruptly, aud declined on a regular line from this last point to the limit of observation. There were slight irregularities in the upper branch of the line iu all cases, but they were easily reduced to a right line, while below very great diversity existed, the surface being much too low or much too high for the average of points of the entire line, and particularly for the point at which the line of 4000 feet would strike, if prolonged in the direction it had through the upper space of 20,000 feet. In the equable climate of England it is well known that much less irregularity exists in regard to surface temperatures than here; and the general difference is exaggerated on the high aud arid plateaus of our interior, where the measures at the warmest and coldest points of the day differ extremely. A large approximate correction must be applied to such readings, if averages by which their extremes are neutralized cannot be obtained, and this becomes more necessary as the altitude is greater, since at high altitudes the primary element of difference of elasticity becomes greatest.

There is, unfortunately, no possible construction of a constant for this correction, but, more nearly than anything else, it is the equivalent of the differeuce betweeu the observation itself and the meau temperature of the month at the place observed. Extreme hours of the day would require some conformity to their readiugs, and the item taken for comparison with averages at sea level for the latitude should be intermediate between the mean for the whole month, and the mean for the observed hour of the month in which the observation is made. Thus if an elevated point is observed at the warmest hour of the day, and a reading of 90° is found, when the meau for the month is 65° and that of the warmest hour 80°, a point intermediate between these is the true measure to be employed. It is well known that the day's curve in the dry and elevated districts of the interior here may go from 32° to 90°, or eveu through a wider range. A calculation based on either of these extremes would give a large error at 5000 feet above the sea.

The diagrams of the balloon ascents alluded to may represent the conditions on a plateau of great elevation here. From these it will at once be seen that this important element of the barometric formula must be detached from the coustaut representing elastic pressure simply, and that it must be considered from the best aids which the conditions of the occasion afford—the object being to attain the best approximation to a line representing the meau decrease of temperature for the atmospheric mass as a whole. To add or subtract 10° or 15° empirically will often be necessary, and for some districts a scale of such corrections may be constructed.

CONSTANTS OF ATMOSPHERIC PRESSURE THROUGH THE SUCCESSIVE MONTHS OF THE YEAR.

The barometric mean for the several months varies but little in the west of Europe and at coast positions in the eastern United States, but in the interior here it changes considerably through a regular curve, changing still more in the interior of the eastern continent. These changes have a climatological distribution also, as in all other cases, and they may have practical importance in barometric survey.

A general statement of the conditions may be made in regard to the land areas in

* Philosophical Transactions for 1852. (Royal Society.)

temperate latitudes, which is, that with the heats of summer the rarefaction reduces the weight of dry air very much, and though the increase in the weight of vapor makes up in part for the removal of dry air, the whole volume has less weight than in the colder part of the year. At the coasts and at sea the reverse occurs to some extent, though the full compensation for the interior rarefaction is probably to be sought at all the borders of the land areas,—those at the north and south, equally with those at the east and west. The barometer is higher in winter and lower in summer therefore at all inland positions, and generally there is a quite regular curve of changes, convex toward the summer months at the western borders of the continent, and concave in the interior. The analogies derived from the eastern continent in other cases must again be used here to illustrate our own incomplete results, and by the aid of both some idea of the law of constant variation may be obtained.

This constant is perhaps only the annual form of the result belonging to the day as a horary variation, or the simple expression of the sun's influence in rarefying an aerial mass subjected to its direct influence. In the interior of Asia the diminution of weight is very great, the barometer reading half an inch lower in summer than in winter; and if the elastic force of vapor be removed, it is found to read an inch and a half lower, or one-twentieth of the entire weight at sea level. There is, unfortunately, no full year of barometric record in the interior of this continent by which the change here may be known, but a few months of observation at some points in New Mexico indicate a considerable diminution of weight in summer. It is probable that the analogies of continental position reproduce analogous conditions, and that in all the arid interior of the United States territory the atmospheric weight is greatly reduced at the season of greatest rarefaction.

Barometric Means, Monthly.

Note.—The second entry at any station has the *Force of Vapor* (the elastic force or weight of all the suspended moisture) subtracted from the monthly averages.

	Jan.	Feb.	Mch.	Apl.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Year.
Greenwich . . .	29.766	.737	.750	.708	.785	.797	.799	.787	.809	.858	.714	.857	29.781
Do. dry air only	29.536	.520	.513	.399	.445	.380	.351	.408	.396	.529	.430	.613	29.460
Paris	29.808	.763	.756	.711	.720	.776	.772	.764	.750	.753	.721	.802	29.758
St. Petersburg, 1st	30.132	29.759	.978	30.077	30.035	29.875	.924	.937	30.079	29.974	.870	.971	29.967
Do. 2d	30.015	30.046	29.953	.970	.961	.917	.855	.898	.970	.956	.883	.933	29.947
Bakou	30.430	30.310	30.244	30.093	30.147	29.996	29.968	30.027	30.217	30.292	30.254	30.277	30.188
Do. dry air . .	30.236	.103	.018	29.788	29.728	29.420	.312	29.375	29.677	29.833	29.918	30.042	29.788
Barnaoul	29.803	.804	.757	.639	.487	.329	.261	.292	.543	.722	.868	.760	29.590
Do. dry air . .	.754	.752	.558	.518	.318	.039	28.876	28.904	29.311	.604	.810	.708	29.420
Pekin, China . .	30.350	30.241	30.086	29.955	29.805	29 676	.594	.709	.898	30.135	30 228	30.259	29.994
Do. dry air . .	.274	.141	29.960	.743	.494	.148	28.881	29.043	.459	.891	30.086	30.162	29.690
Sitka, Russ. Amer.	29.745	.799	.804	.877	.922	.969	.999	.957	.876	.761	.676	.660	29.837
Do. dry air . .	29.627	.619	.676	.683	.678	.673	.637	.564	.546	.506	.475	.471	29.595
Toronto, Can. . .	29.618	.614	.622	.657	.565	.577	.589	.635	.647	.663	.626	.643	29.621
Do. dry air . .	29.454	.396	.501	.398	.324	.164	.193	.218	.231	.408	.419	.487	29.350
Cambridge, Mass.	30.024	29.993	.982	.991	.959	.915	.967	30.035	30.044	30.029	29.986	30.017	29.998
Philadelphia . .	29.960	.907	.942	.924	.886	.891	.916	.943	.971	.949	.941	.957	29.932
Do. dry air . .	29.792	.836	.718	.626	.502	.306	.315	.321	.479	.637	.723	.784	29.590
Washington . .	30.147	.112	.020	.029	29.965	29.953	29.990	30.031	.067	.133	.107	.060	30.051
Do. 1⅓ yrs. dry air	29.919	29.888	29.716	29.685	.536	.307	.275	29.323	29.473	29.835	29.856	29.822	29.636
St. Louis	29.616	.618	.598	.540	.493	.495	.544	.567	.584	.619	.623	.630	29.578
Cincinnati . . .	29.335	.308	.315	.295	.245	.271	.331	.356	.346	.374	.349	.356	29.323
Hudson, Ohio . .	29.834	.816	.759	.785	.710	.757	.828	.846	.870	.846	.844	.777	29.806
Glenwood, Tenn.[1]	29.726	.674	.604	.513	.567	.604	.607	.618	.592	.586	.607	.630	29.611
Pará, Brazil, 3¼ yrs.	29.910	.926	.914	.943	.952	.982	.992	.988	.946	.931	.907	.897	29.941

[1] 3 years.

The following are the authorities and sources of the barometric observations from which the curves are constructed.

Greenwich observatory, 8 yrs., 1841 to 1848; from Col. Sabine's paper in Phil. Trans. Royal Society for 1850, obs'ns bi-hourly.

Paris, 30 years, 1816 to 1845. Annuaire Meteorologique for 1849; obs. at 9, 12, 3 and 9.

Bakou, Caspian Sea, Asia; Lat. 40° 22', Long. 50° east; one year, Dec. 1851, to Dec. 1, 1852. Annales Observatory Physique for 1852.

Pekin, China, 3 years, 1847–1849. Obs. bi-hourly from 5 a. m. to 9 p. m. Russian Annales Obs. Phys.
Sitka, Russian America, 10 years, 1833 to 1842. Memoirs Imp. Acad'y St. Petersburg, 1848.
Cambridge, Mass. 12 years, 1841 to 1852. Prof. Bond—Obs. at sunrise, 9, 3 and 9. *Am. Alm.*
Philadelphia, 5½ years, Girard College Observatory; obs'ns hourly and bi-hourly.
Washington, 4 years, 1838–1842, Naval Observatory; curve of dry air for 1½ years.
St. Louis, 12 years, 1837 to 1848—Dr. Engelmann's obs'ns at 12 m. reduced.
Cincinnati, 14 years, 1835 to 1848—Dr. Ray's obs'ns at three hours daily.
Hudson, Ohio, 3 years, 1838–1840; obs'ns by Prof. Loomis.
Para, Brazil, 3¼ years, April 1846 to June 1849 by Henry Bond Dewey, U. S. Consul, MS., not corrected for temperature; the yearly mean temperature is 80°.5.

In review of the curves presented by these observations, (Plate XIII.) the contrast of opposite continental coasts is the most striking fact disclosed. At Greenwich and Paris the pressure is nearly the same for each month, showing some interesting minor changes at the beginning and end of the year, however, which have a philosophical interest, but space does not permit discussion of them here. Cambridge, Philadelphia, and Toronto, also have a nearly uniform march of the pressure through the year, the summer being slightly lower, but if the elastic force of vapor is removed we find a large downward curvature for the line, showing that the greater humidity of the summer atmosphere preserves the average pressure for these months, when in more arid climates it is diminished very much by the same measures of heat.

The importance of this point in engineering by the aid of barometric observations will be seen by reference to the Asiatic observations, where the differing mean of the extreme months, as at Barnaoul, is six-tenths of an inch of the barometer, or the equivalent of near six hundred feet of altitude. There are yet no interior points observed here where comparison may be made, yet it is doubtless not less than three or four-tenths of an inch, equivalent to nearly as many hundred feet of altitude. In this case, as in that of horary variation, it will not serve to compare the observations of like months, or the summer month in the interior with observations for the same month on the Pacific or Gulf coast, as the contrasted positions of the curves, or the absence of any depression in the last case, renders the observations not comparable without correction of the error which belongs to one alone. It will be safe, at least, to hold all such results as approximate until the actual relation of pressure for the months is known.

The elastic force of vapor is shown to be an important element of the sum of atmospheric weight, particularly at interior and continental positions, but its proportion or quantity does not affect barometric engineering in any degree. A statement of the distribution of this elastic force in a view similar to that taken of the previous constants would be less complete than in their case, as the observations of the temperature of evaporation, or the wet-bulb thermometer, are not uniform at all stations. Generally this element of weight is greatly increased in summer and diminished in winter, and it is greater also in the arid interior districts than on the most humid coasts. It increases directly with the temperature, and it is identical with the power represented in the expansive force of steam. Regnault's accurate experiments on this force, in every degree it presents from the highest steam power to the least difference between the wet and dry bulb of the air thermometer, have established the rules for deriving every degree of it exhibited in the atmosphere from the readings of the wet and dry thermometer. The increase of its expansive force under the rapid increase of temperature assists in the atmospheric displacement from the continental areas in the summer months, and in the production of the peculiar curves of depression exhibited at the interior Asiatic stations. The value of this elastic force is the difference between the full readings of the barometer first given and the measures given for "dry air," and this may be readily taken for every station where the two curves are given. At Washington and Philadelphia, as well as at Pekin and the Caspian Sea, it is more than half an inch of the barometer at mid-summer, or one-sixtieth of the entire atmospheric weight.

The great aid afforded to this inquiry by the Russian observatories deserves the highest acknowledgment, and their appreciation of this important change in the atmospheric weight over the great continental areas is shown by the following allusions taken from the Memoirs of the Imperial Academy of St. Petersburg for 1848. "It is already known (and it is M. Dove again who first directed attention to the subject) that in the interior of Siberia the barometric mean is considerably less during the summer months than in those of winter. It appears that this is the law for all Asia, the same phenomenon being observed at Pekin and Bombay. (See for the first the observations of M. Gatchkevitch published in the Annuaire Magnet. and Meteorol. du Corps des Mines, and for the last the interesting report of Col. Sabine (in the Phil. Mag. for 1845,) and the observations of M. Middendorff, made in the most distant north of Siberia, on the borders of the river Bajanida (peninsula of Taimour) during May, June, July and August 1843, give also for June a considerable fall of barometer.)

On the coast of North America, on the contrary, the barometric height is greater in summer than in winter. It would be interesting to know the barometric movement on the eastern coast of Siberia, and a factory (post) at Aran, near Okhotsk, has, on the request of the Academy, established a meteorological station there."

The observations at Parà, in Brazil, latitude 1° 28′ south, and longitude 49° 28′ west, are introduced for comparison of tropical curves in this connection. That locality is more perfectly equable in its temperature than any other point yet observed on the American continent, and the change of atmospheric weight through the months has no relation to changes of the temperature at the surface. The barometric readings are not corrected for temperature, and the annual mean of 80° applied to this reduction, supposing the barometer to be one of brass scales, would give 29.804 inches as the mean annual pressure. But as this correction is not known to be applicable, the curve among the months may be taken as the only positive result. The change conforms in some respect, though not wholly, to the rainy and dry seasons, the last six months of the year being generally dry, and the first half rainy.

These observations are from the manuscript of the late Henry Bond Dewey, U. S. Consul at Parà.

CONSTANTS OF THE TEMPERATURE MARCH FOR THE YEAR.

The distribution of heat for the successive months and days of the year is far from being uniform for all parts of the temperate latitudes, and the yearly extremes of heat and cold vary in position more than might at first be supposed. The winter and summer solstices would mark these extremes of accumulation of heat first, and refrigeration next, were not each retarded by the operation of laws inherent to the fluid or condition we designate as heat. In both summer and winter a month is required to overcome the local effect, and to bring the measure of heat to its highest point in the first case, and to its lowest in the next, corresponding to the sun's position; the greatest heat is on the average near July 20th, though the highest point of the sun is on June 21st; and the greatest cold January 20th while the sun is lowest December 21st. About these points there are large variations however, the general character of which is to place both points at later dates in continental positions, and at the eastern districts of the continental areas of temperate latitudes; and to place them earlier in maritime positions, and in those bordering the tropics and the west coasts of the continents.

Long periods of observation are required to place the daily extremes for the year correctly, because of the very great measures of non-periodic variation, and the most extensive series yet discussed in this manner, that at Berlin, still fails to give symmetry in the averages with such clearness as to establish the points within two or three days. A graphic interpolation and correction will give a close approximation

however, and such we are compelled to employ in most cases. The following are the daily averages for the solstices and equinoxes derived from observations for *one hundred and ten* years at Berlin, Prussia, previous to 1840; (*Am. Met. de France*, 1850,) and they do not sensibly differ from the points derived from a graphic projection of the curve among the months, derived from the monthly means.

		°			°
Extreme of heat,	July 23d	66.0	Extreme of cold,	Jan. 8	28.6
	" 24	66.2		" 9	27.5
	" 25	66.9		" 10	27.6
	" 26	67.2		" 11	28.5
	" 27	67.0		" 12	29.2
	" 28	66.7	Vernal equivalent of yearly mean	Apl. 16	47.7
	" 29	66.7		" 17	48.2
	" 30	67.2			
	" 31	67.1	Autumnal equivalent of yearly mean	Oct. 16	48.5
	Aug. 1	66.9		" 17	47.8

The annual mean is here 48°.1, and the means of the observations thus summed up for each day show that this point is passed through on the 16th and 17th of each, April and October, placing the resulting equal distribution of heat twenty-seven days after each equinox, or mean of the sun's position.

If these observations are to be relied upon the cold extreme is there thrown forward to the tenth of January only, while the summer maximum goes to July 28th. The cold extreme and vernal mean are thus nearly *twenty* days and *twenty-seven* days respectively from the solar points, and the warm extreme and autumn mean *thirty-eight* and *twenty-seven* days, respectively, forward from the natural positions. The period of increasing heat is longer than that of decrease by the difference of these positions, or there are *one hundred and ninety-nine days* of increasing temperature to *one hundred and sixty-six* of declining temperature; an excess of thirty-three days, which is mostly a prolongation of summer and autumn heat.

This position represents all the west of Europe quite correctly, and in all parts of it the extreme of winter cold comes several days earlier than in the United States, at the same time that the summer and autumn heat go at least as far forward, and usually to a later day. At Mitau, a Russian city near the Baltic, and intermediate between Berlin and St. Petersburg, the mean of 25 years of observation closing with 1848, computed in means for periods of five days each, gives the following positions for the points under consideration.

	°		°		°
Jan. mean of 1st 5 days,	21.9	July, m'n of 1st 5 days,	62.8	Apl., 3d 5 days,	39.9
" " 2d "	21.8	" " 2d "	63.9	" 4th "	42.1
" " 3d "	21.6	" " 3d "	65.5	" 5th "	44 7
" " 4th "	21.6	" " 4th "	63.7	" 6th "	46.5
" " 5th "	21.8	" " 5th "	62.8	Oct. 2d "	47.4
" " 6th "	22.0	" " 6th "	63.9	" 3d "	45.2
		Aug. " 1st "	64.5	" 4th "	42.7
		" " 2d "	63.3	" 5th "	41.5
				" 6th "	39 5

The yearly mean is here 42°.9, which would be passed nearly at April 18th in the spring, and at October 18th, nearly, in autumn. The greatest cold is January 15th, and the greatest heat July 18th. A summary at the same station including four years more of observations, to 1852, brings the winter extreme about January 10th, and the summer extreme July 28th, the other points not being altered.

The mean temperatures of the months embracing these points at several European positions will show the early occurrence of the winter minimum, and the relation of April and October to the annual mean.

	Jan.	Feb.	July	Aug.	April	Oct.	Yearly Mean.
	°	°	°	°	°	°	°
Berlin	27.7	31.6	65.8	64.4	47.4	49.9	48.1
Konigsberg	24.4	26.9	62.6	61.7	41.4	43.7	43 2
St. Petersburg	15.7	17.5	62.7	60.8	35.6	40.6	38.7
Zwanenberg, Holland	34.2	37.1	63.4	63.8	47.3	51.4	49.4
London	37.2	40.1	62.4	62.1	46.9	50.7	49.7
Paris	35.4	39.5	65.6	65.3	49.7	52 2	51.3
Milan	33.2	38.3	74.6	73.4	54.6	56.3	54.9
Vienna	29.3	33.5	70.7	70.0	51.8	51.2	51.0
Taganrog	20.7	21.2	72.1	71.6	47.3	47.3	46.8
Kasan	3.5	8.1	64.8	60.9	36 3	37.1	35.5
Irkutzk	—3.3	4.8	64.8	59.2	36.2	33.9	32 6
Pekin	25.5	30.8	77.7	75.5	56.5	54.1	53 2
Canton	52.5	55.0	83.0	82.0	70.0	73.3	69.9

The stations of the west of Europe are the most reliable of those given here, and the first point apparent is that the January minimum cannot be far from the middle of January. The mean difference of January and February for the stations cited is $3^{\circ}.5$, and the same difference from December is $4^{\circ}.2$; thus throwing the lowest point forward a little, and placing it near the 18th.

Next the measures for July and August differ little, the average being for the same stations but 8-tenths of a degree; and this fact necessarily places the summer maximum near the close of July, and probably at the point indicated in the Berlin series, the 28th. At Zwanenberg 92 years of observation give a higher temperature for August than for July, and 12 years at Amsterdam, with 10 at Brussels, give exactly equal heat for the two months. There can be no doubt that the west of Europe has the highest point of summer heat within three or four days of the close of July.

For the representatives of the yearly mean, and the point where the annual march cuts that line, we find April always below and October always above it; and the differences in the first case are so considerable in the British Islands and northwest that the points must be placed later in each month than the 20th, or more than a month after the equinoxes. The average difference of April from the annual mean is there nearly three degrees, and this is half the difference between April and May; the point must be placed near the 28th of this month for that part of Europe, or 38 days after the equinox. On the continent the difference decreases, and it appears to disappear at the Mediterranean; for these districts the point would change from April 20th to the 15th. In the interior and east the case is reversed, the month being warmer than the yearly mean by differences which increase to three and four degrees at Irkutzk and Pekin. The point representing the annual mean is there thrown earlier, though as the difference between the months is greater—amounting to $16^{\circ}.2$ between March and April at Irkutzk—the change in date is less than for opposite differences in the west of Europe, and the 8th or 10th of April would probably be the earliest day at which the annual mean would be reached in the march of temperature for the year.

The relative position of October is much more uniform; in all cases it is warmer than the year, and the difference varies from one to three degrees. Its representative in time would be the 18th or 20th of this month for the day on which the temperature equals the annual mean. In this division of the year that which may be called the summer varies, therefore, from 196 days in Asia and the east of Europe, to 185 in the west of Europe. Howard gives these periods as the 24th or 26th of April, and the 22d or 23d of October at London, and at the 12th to 25th of each, January, and July, for the extremes, but these positions are founded on periods of observation inadequate to render the results uniform for the days embracing these points.

In several memoirs cited by Col. Sabine* the reduction of the best observed series

* In a Memoir on the Periodic and Non-Periodic variations of Temperature at Toronto, *Phil. Trans.*, for 1852.

has been given for a number of positions in central Europe, with the results found in the following table. Their diversity is such that there must necessarily be much discrepancy in the modes of determining these points.

	Day of maxim.	Day of minim.	Days on which the mean of the year is passed through.	
Konigsberg, Bessel	Aug. 1	Jan. 9	Apl. 21	Oct. 20
Berlin, Mädler (18 yrs.)	July 18	Jan. 19	Apl. 19	Oct. 21
Berlin, " (92 yrs.)	July 22	Jan. 12	Apl. 17	Oct. 16
Prague, Fritsch, (8 to 9 yrs.)	July 24	Jan. 26	Apl. 16	Oct 20
Prague, Jelinek, (76 yrs.)	July 23	Jan. 19	Apl. 15	Oct. 18
Paris, Kaemtz	July 28	Jan. 15	Apl. 18	Oct. 19
Turin, Kaemtz	July 27	Jan. 3	Apl. 18	Oct. 26
Padua, Kaemtz	July 26	Jan. 15	Apl. 20	Oct. 15
Toronto, Sabine (1841 to 1852.)	July 28	Feb. 12	Apl. 25	Oct. 17

The differences at the same post for differing periods are considerable in both cases where the two periods are given, and it is obvious that long periods, and a grouping of results in addition, are necessary to bring out a symmetrical result. A graphic interpolation between the monthly means answers the purpose of fixing the point nearly as well as the best reduction of hourly observations, also.

From these European positions for the constant curve of temperature for the year the most easterly American station observed gives some decided contrasts for the points where the annual mean is passed. They are at May 1st and November 4th, forty-one and forty-four days after the equinoxes; while the winter and summer extremes are thirty days each after the solstices. These observations are at Pictou, Nova Scotia, and their author, Henry Poole Esq., has carefully reduced the daily observations for ten years to obtain the curve. The practical effect of this change of position is a great extension of the natural divisions of summer and winter, and a shortening of the spring and autumn. The first are of 116 and 120 days respectively, and the last of 66 and 63 days; the first named being nearly double the second. It is noticeable that this does not agree with the curve at Pekin, which has April warmer than the year, while at Pictou it is 4°.7 colder, the mean of April and May being nearly the annual mean; October is as much warmer, and the mean of this month and November together is *still warmer* than the mean for the year.

At Toronto this remarkable extension of the summer and winter forward, without changing the position of their extreme points, is in great part removed, and the mean for the year is passed through on April 19th, and October 15th. It is apparent that the extension observed in Nova Scotia is a peculiarly maritime feature, belonging to coast exposures only, and perhaps reproduced in Japan and the Asiatic Islands.

At Toronto a new anomaly appears in Col. Sabine's analysis of the twelve years of observation at that observatory, closing with 1852, which is an extraordinary extension of the winter minimum, to the 14th of February. But this period embraces one year, 1843, of an extreme low temperature for February and March, which, combined with a high temperature for January, serves to displace the extreme point fifteen days or more. It will have been seen that the annual extremes are in most if not all cases equally removed from the solstices;—they are so at London and at Pictou, Nova Scotia, and here we find the summer maximum at July 28th, or in its natural position nearly, while the winter minimum for this period is removed fifty-five days from the solstice. A comparison of the monthly means at other American stations will show how far this inference, that the result at Toronto is due to a single extreme of non-periodic variation, is supported by other series.

The mean of results at twenty of the most considerable stations from the coast of Maine to the western extremity of the Lake District gives eight-tenths of a degree for the excess of February over January, and 3° for the decrease from December to January. At three of these stations the mean for January is slightly above that for

February, and nearly all the stations embrace the extreme year, 1843. The inference is irresistible that no part of this district could have a constant point of extreme cold thrown into February, and the average of all the inland positions near the lakes would place the coldest day nearly at January 25th. Beyond this in all directions,—at Quebec, the coast of Maine, Massachusetts, Pittsburgh, Ohio, and the western shore of Lake Michigan—the extreme point is not later than Jan. 25th, and in many cases at the 20th.

At the south along the Atlantic coast the difference of the two months, January and February, averages 2°.8 for the principal series from Baltimore to Beaufort, N. C., inclusive, and from December to January the change is 3°.7. From Charleston to Pensacola the fall of temperature from December is but 1°.2, and the rise to February 2°.8 ; *for the first time throwing the coldest point of the year before the middle of January.* From Mobile to New Orleans there is but one degree of decline from December, and 3°.2 increase to February, and for a group of military posts northwest of New Orleans, from Nachitoches to Fort Gibson, *December is the coldest month of the year.* For six principal posts there, embracing an aggregate of 105 years of observation, January is 0°.7 warmer than December, and February 1°.9 warmer ; a distribution which would throw the point of extreme cold within two or three days of the December solstice. This is a remarkable fact, which does not seem to be paralleled in all eastern temperate latitudes, and it contrasts strongly with the extension of this period forward in the Toronto district.

At all points of the western interior the cold extreme is early in January, and February is warmer than December ; St. Louis, Cincinnati, and Fort Snelling agree in this respect. In New Mexico the same distribution exists, and at some points December is the coldest month. On the Pacific coast for the last eight or ten years December is in all cases the coldest month, and this by so much of difference as to place the minimum near the solstice, as in the interior district of Upper Louisiana. There are evidences of a similar tendency at some points of the southwest of Europe, but Lisbon alone shows it so decidedly as to give the differences found on the Pacific coast, and all points near the Mediterranean have January much the coldest month.

The yearly extreme of high temperature does not change position so much in the districts just reviewed, and it never falls earlier than the middle of July ; the earliest point is attained near New Orleans where June and August differ very little, but generally there is at least one degree of excess in the last month over the first for the southern districts, and in the interior it increases to two and three degrees. In New Mexico it is the same, but the Pacific coast is so variable from local and peculiar causes, that no summer maximum can be defined ; the warmest month varying in position from June to October, though the differences are always slight.

The points in which the annual mean is passed approach the middle of April and of October, on going southward from Philadelphia, more nearly than at the north. At this point they are 1°.5 each from the annual mean, April colder and October warmer ; at Charleston 1°.2 each ; at Pensacola and Tampa Bay April is nearly the same temperature, while October is 2° warmer than the year ; at Mobile and New Orleans both are warmer, and April by much the largest measure ; at Baton Rouge and Nachitoches *April is one degree warmer and October one degree colder ;* at the group of stations near Fort Gibson both become one to two and a half degrees warmer than the year, and this is the case in all parts of Texas. At St. Louis and vicinity April is 3° warmer than the year, and October at the same temperature ; at Cincinnati and Marietta, Ohio, both are quite the same as the annual mean ; in the western lake district each differs 3°,—April colder and October warmer ; and on the western plains, represented by Forts Snelling and Leavenworth both are much warmer, and April has the highest temperature.

On the Pacific coast there is much irregularity, and the periods of observation are

insufficient to fix the conditions with any accuracy. Generally the two months are nearly the representatives of the year, and the changes from this position are very variably placed. In undertaking the definition of this line of annual march without condensing the daily observations the positions are of course approximate, yet where such daily observations are employed the most extended periods have failed to remove all irregularities, leaving the points still nothing more than approximations. The following tabular arrangement of the results will perhaps sufficiently show the constant annual curves for the present purpose.

Distribution of the Constants of the Yearly Curve of Temperature.

	Date of winter minimum, and days after solstice.		Date of summer maximum, and days after solstice.		Vernal equivalents of the year, and days after equinox.		Autumnal equiv't of y'r, and days after equinox.		Days above the mean.	Days below the mean.
Nova Scotia, &c.	Jan. 21	30	July 22	30	May 1	41	Nov. 4	44	188	177
Boston, &c.	Jan. 25	34	July 25	34	April 23	32	Oct. 23	32	183	182
Toronto, Observatory	Feb. 14	55	July 28	37	April 19	29	Oct. 15	24	179	186
Toronto District	Jan. 28	37	July 28	37	April 20	30	Oct. 20	30	183	182
Philadelphia, &c.	Jan. 21	30	July 25	34	April 18	28	Oct. 21	31	187	178
Baltimore to Beaufort	Jan. 18	28	July 25	34	April 18	28	Oct. 18	28	184	181
Charleston to Pensacola	Jan. 10	20	July 21	31	April 15	25	Oct. 18	28	180	185
Móbile to New Orleans	Jan. 5	15	July 15	25	April 8	18	Oct. 15	25	185	180
Nachitoches, &c.	Dec. 23	2	July 18	28	April 10	20	Oct. 10	20	183	182
Fort Gibson, district	Dec. 23	2	July 20	30	April 10	20	Oct. 20	30	193	172
St. Louis, &c.	Jan. 8	18	July 20	30	April 8	18	Oct. 15	25	190	175
Cincinnati and Marietta	Jan. 10	20	July 20	30	April 15	25	Oct. 15	25	183	182
Mackinac, &c.	Jan. 30	40	July 28	37	April 25	35	Oct. 25	35	183	182
Fort Snelling, &c.	Jan. 8	18	July 20	30	April 6	16	Oct. 23	33	200	165
New Mexico	Jan. 5	15	July 22	32	April 15	25	Oct. 15	25	183	182
San Diego, &c.	Dec. 21	0	Aug. 10	51	April 20	30	Oct. 28	38	191	174
San Francisco, &c.	Dec. 28	7	Sep. 21	90	April 15	25	Nov. 10	50	208	157
Interior Cal , Ft. Miller, &c.	Jan. 1	10	July 18	28	April 20	30	Oct. 25	35	188	177
Puget's Sound	Jan. 5	15	July 25	35	April 22	32	Oct. 22	32	183	182
Sitka, Russ. Amer.	Dec. 25	4	Aug. 10	50	April 20	30	Oct. 15	25	178	187

If the position of this constant is fixed with sufficient accuracy for the present purpose of general definition, as it is believed to be by the use of groups of monthly results, we have an interesting view of the distribution of the points for the whole continental area in temperate latitudes here. It is singular that the winter minimum should come at the solstice anywhere, and particularly so in the interior above Nachitoches; and it is found to range from this normal point of Dec. 21st to the first of February, at least, if the extreme position at Toronto is still regarded as a non-periodic variation. The summer maximum is always at least 25 days removed from the solstice however, and in California there are some extraordinary removals; but on the whole its position varies little. The yearly mean in spring also varies less than a month, the extremes being April 6th at Fort Snelling and May 1st at Nova Scotia, both in nearly the same latitude, and perhaps contrasting the extremes naturally belonging to interior and maritime positions. The autumnal cold falls earliest at Nachitoches and latest at San Francisco, though in the climates of a regular curve Nova Scotia presents the greatest prolongation of autumnal heat.

The most extended period of a temperature above the mean is at San Francisco, where the nearly horizontal summer line is necessarily much prolonged. Next Fort Snelling, St. Louis, and Fort Gibson show a long summer period, which is due to the sharpness of the winter cold, and its great depression below the heat of summer.

HYGROMETRIC TABLE; CONSTANTS OF ATMOSPHERIC HUMIDITY.

The most valuable definitions in climatology next to the simple quantities of heat and of water falling in rain, are those belonging to the moisture suspended in the air, or to *humidity*. The observation has heretofore been made by various forms of hygrometers, but it is now quite universally agreed to drop the hygrometers acting by absorption, which are usually constructed of vegetable or animal fibre, and to take the *temperature of evaporation* simply, or the readings of a thermometer covered with moistened gauze. This is a simple, direct, and decisive expression, and the significance of the condition at any time is at once understood by the difference between the wet and dry thermometers. In the American climate this difference may reach 25° in the desert interior, but in the eastern States a difference of more than 15° is rare.

There are two positive constants derivable from these differences, which are so constantly necessary in climatological comparisons as to require a table adapted to immediate use. These are the *percentage of saturation*, and the *elastic force* of the vapor in the air. The first is the proportion of moisture present to what the air may contain when fully saturated at the same temperature ; and the second is the weight of the vapor present as indicated by the barometric column, or in inches of mercury. This may readily be converted into absolute weight in pounds on the square foot of surface. Both these constants are calculated from Regnault's elements, whose researches into the expansive force of steam, and of suspended atmospheric vapor, which is precisely the same element, perfectly harmonized the theoretical calculation of these forces with the actual result as found by the most extended and elaborate experiments. The theoretical calculation of these from the temperature of evaporation was somewhat modified in the discussion, but the formula as at last constructed by him correspond perfectly with the results of experiment at all temperatures above 32°. For temperatures below 32° an allowance has usually been made for the heat rendered latent by the conversion of water into ice, but subsequent experiments have rendered it doubtful whether the consideration of this latent heat should enter into the calculation of observations within a few degrees of the freezing point. At low temperatures accurate observation is also extremely difficult, and the practical use of the table is little required.

The table given here has been calculated for this work from Regnault's elements by Professor Kirkpatrick, and it is believed that the form is the best which can be given it,—the intermediate differences given in the tables constructed by Guyot and others, being readily supplied by interpolation. The formula may be used to extend the table, if larger differences are observed, by using the *maximum elastic force*, which is given for air temperatures at saturation, from 20° to 100°. It will rarely be necessary to go beyond 25° of difference.

In the following formula, which is explained by the discussion which succeeds it, $x = f' - \frac{0.480\,(t - t')}{1130 - t'}\,h$;—in which f' is the elastic force of vapor at saturation for the observed dry air temperatures; t, the reading of the dry thermometer, t', the wet thermometer, h, the barometric reading, and x the elastic force sought. The relative humidity is the simple proportion of the elastic force, at any difference of the two thermometers, to the maximum elastic force at that degree of the wet thermometer.

M. Gay Lussac first proposed the hygrometer of evaporation from a wet-bulb thermometer. M. August then occupied himself with this question, and constructed a formula for it—calling the apparatus composed of the two thermometers a *psychrometer*. (*Ann. de Chimie*, 2e series, t. xxi., p. 91 ; and t. v., p. 69.) For the full discussion see Regnault's various papers in *Annales de Chimie et Physique*, mainly in tome xv., 1845, and the *Annuaire Meteorologique de France*, for 1849 and 1850.

HYGROMETRIC TABLE; *Relative Humidity and Force of Vapor;*
[Using Regnault's Elements;]

t'	*t—t', Difference of Wet and Dry Bulb Thermometers.*																			
Wet therm.	1°		2°		3°		4°		5°		6°		7°		8°		9°		10°	
	R. H.	F. V.	R. H.	F. V.	R. H.	F. V.	R. H.	F. V.	R. H.	F. V.	R. H.	F. V.	R. H.	F. V.	R. H.	F. V.	R. H.	F. V.	R. H.	F. V.
	pr. ct.	in.	pr. ct.	in.	pr. ct.	in.	pr. ct.	in.	pr. ct.	in.	pr ct.	in.	pr. ct	in.	pr. ct.	in.	pr. ct.	in.	pr. ct.	in.
21°	85	.100	70	.087	57	.074	45	.061	34	.048	24	.035	14	.022	6	.009				
22	85	.105	71	.092	59	.079	47	.066	36	.053	26	.040	17	.027	8	.014				
23	86	.110	72	.097	60	.084	49	.071	38	.058	28	.045	19	.032	11	.020	4	.007		
24	86	.116	73	.103	61	.090	50	.077	40	.064	30	.051	22	.038	14	.025	6	.012		
25	86	.122	74	.109	62	.096	52	.083	42	.070	32	.057	24	.044	16	.031	9	.018	2	.005
26	87	.128	75	.115	63	.102	53	.089	43	.075	34	.062	26	.049	18	.036	11	.023	5	.011
27	87	.134	75	.121	65	.108	54	.095	45	.081	36	.068	28	.055	21	.042	14	.029	7	.016
28	88	.140	76	.127	65	.114	55	.101	46	.087	38	.074	30	.061	23	.048	16	.035	10	.023
29	88	.147	77	.134	66	.120	57	.107	48	.094	40	.081	32	.068	25	.055	19	.042	12	.029
30	88	.153	78	.140	67	.127	58	.114	50	.101	42	.088	35	.075	27	.062	21	.049	14	.036
31	89	.161	78	.147	69	.134	59	.121	51	.108	43	.095	37	.082	29	.069	23	.056	17	.043
32	89	.168	79	.155	69	.142	61	.129	53	.116	45	.103	38	.090	31	.077	25	.063	19	.050
33	89	.175	79	.162	70	.149	62	.136	54	.123	46	.110	39	.097	32	.084	26	.071	21	.057
34	90	.183	80	.170	71	.157	63	.144	55	.130	47	.117	40	.104	34	.091	28	.078	22	.065
35	90	.191	81	.178	72	.165	64	.152	56	.138	49	.125	42	.112	36	.099	30	.086	24	.073
36	90	.199	81	.186	72	.173	64	.160	57	.146	50	.133	43	.120	37	.107	31	.094	26	.081
37	90	.207	82	.194	73	.181	65	.168	58	.155	51	.142	45	.129	38	.115	33	.102	28	.089
38	91	.216	82	.203	74	.190	66	.177	59	.163	52	.150	46	.137	40	.124	34	.111	29	.098
39	91	.225	82	.212	74	.199	67	.186	60	.172	53	.159	47	.146	41	.133	36	.120	31	.107
40	91	.234	83	.221	75	.208	68	.195	61	.182	54	.169	48	.155	42.	.142	37	.129	32	.116
41	91	.244	83	.231	75	.218	68	.204	61	.191	55	.178	49	.165	44	.152	38	.139	33	.125
42	92	.254	83	.241	76	.228	69	.214	62	.201	56	.188	50	.175	45	.162	40	.149	35	.135
43	92	.265	84	.252	77	.238	70	.225	63	.212	57	.199	51	.185	46	.172	41	.159	36	.146
44	92	.275	84	.262	77	.249	70	.236	64	.223	58	.209	52	.196	47	.183	42	.170	37	.156
45	92	.286	84	.273	78	.260	71	.246	65	.233	59	.220	53	.207	48	.194	43	.180	39	.167
46	92	.298	85	.285	78	.272	71	.258	65	.245	60	.232	54	.219	49	.205	44	.192	40	.179
47	92	.311	85	.297	78	.283	72	.270	66	.257	60	.244	55	.230	50	.217	45	.204	41	.191
48	92	.323	85	.310	79	.295	73	.282	67	.269	61	.255	56	.242	51	.229	46	.216	42	.202
49	93	.335	86	.322	79	.308	73	.295	67	.282	62	.268	57	.255	52	.242	47	.228	43	.215
50	93	.348	86	.334	80	.321	74	.308	68	.294	63	.281	58	.268	53	.254	48	.241	44	.228
51	93	.361	86	.348	80	.335	74	.321	68	.308	63	.295	58	.281	54	.268	49	.255	45	.241
52	93	.375	87	.362	80	.348	75	.335	69	.322	64	.308	59	.295	54	.282	50	.268	46	.255
53	93	.390	87	.376	81	.363	75	.350	70	.336	64	.323	60	.309	55	.296	51	.283	47	.270
54	93	.404	87	.391	81	.378	76	.364	70	.351	65	.338	60	.324	56	.311	52	.298	48	.284
55	94	.420	87	.407	82	.393	76	.380	71	.367	66	.353	61	.340	57	.327	53	.313	48	.300
56	94	.436	88	.422	82	.409	76	.396	71	.382	66	.369	62	.355	57	.342	53	.329	49	.315
57	94	.452	88	.439	82	.426	77	.412	72	.399	67	.385	62	.371	58	.359	54	.345	50	.332
58	94	.469	88	.456	82	.442	77	.429	72	.415	67	.402	63	.388	59	.375	55	.362	51	.348
59	94	.487	88	.473	83	.460	77	.447	73	.433	68	.419	63	.406	59	.393	55	.380	52	.366
60	94	.505	88	.491	83	.478	78	.464	73	.451	68	.437	64	.424	60	.411	56	.397	52	.384
61	94	.524	89	.510	83	.497	78	.483	73	.470	69	.456	65	.443	61	.429	57	.416	53	.403
62	94	.543	89	.529	83	.516	79	.502	74	.489	69	.475	65	.462	61	.448	57	.435	54	.422
63	94	.563	89	.549	84	.536	79	.522	74	.509	70	.495	66	.482	62	.468	58	.455	54	.442
64	94	.583	89	.569	84	.556	79	.542	75	.529	70	.515	66	.502	62	.488	58	.475	55	.461
65	94	.604	89	.591	84	.577	80	.564	75	.551	71	.537	67	.523	63	.510	59	.497	56	.483
66	95	.626	89	.612	84	.599	80	.585	75	.572	71	.558	67	.545	63	.531	60	.518	56	.504
67	95	.648	90	.635	85	.621	80	.608	76	.594	71	.581	67	.567	64	.554	60	.540	57	.526
68	95	.671	90	.658	85	.644	80	.631	76	.617	72	.604	68	.590	64	.577	61	.563	57	.549
69	95	.695	90	.681	85	.667	81	.654	76	.641	72	.627	68	.614	65	.600	61	.587	58	.573
70	95	.720	90	.706	85	.692	81	.679	77	.665	72	.652	69	.638	65	.625	62	.611	58	.598
71	95	.745	90	.731	85	.718	81	.704	77	.691	73	.677	69	.664	66	.650	62	.636	59	.623
72	95	.771	90	.757	86	.744	81	.730	77	.717	73	.703	70	.689	66	.676	63	.662	59	.649
73	95	.798	90	.784	86	.771	82	.757	78	.743	74	.730	70	.716	66	.703	63	.689	60	.676
74	95	.825	90	.812	86	.798	82	.785	78	.771	74	.757	70	.744	67	.730	64	.717	60	.703
75	95	.854	91	.841	86	.827	82	.813	78	.800	74	.785	71	.772	67	.758	64	.745	61	.732
76	95	.884	91	.871	86	.857	82	.842	78	.829	75	.815	71	.801	68	.788	64	.774	61	.761
77	95	.914	91	.900	87	.886	82	.873	79	.859	75	.845	71	.832	68	.818	65	.804	62	.791
78	95	.945	91	.930	87	.917	83	.904	79	.890	75	.876	72	.863	68	.849	65	.835	62	.822
79	95	.977	91	.963	87	.949	83	.936	79	.922	75	.908	72	.895	69	.881	65	.867	62	.854
80	96	1.010	91	.996	87	.982	83	.969	79	.955	76	.941	72	.928	69	.914	66	.900	63	.886
81	96	1.043	91	1.030	87	1.016	83	1.002	80	0.989	76	.975	73	.961	69	.948	66	.934	63	.920
82	96	1.078	91	1.065	87	1.051	84	1.037	80	1.024	76	1.010	73	.996	70	.983	67	.969	64	.955
83	96	1.114	91	1.101	87	1.087	84	1 073	80	1.060	76	1.046	73	1.032	70	1.018	67	1.005	64	.991
84	96	1.151	92	1.138	88	1.124	84	1.110	80	1.096	77	1.083	73	1.069	70	1.055	67	1.042	64	1.028
85	96	1.189	92	1.176	88	1.162	84	1.148	80	1.134	77	1.121	74	1.107	71	1.093	68	1.079	65	1.066

Calculated for the Readings of the Wet Bulb Thermometer;
By Prof. JAMES A. KIRKPATRICK.

MAXIMUM ELASTIC FORCE OF AQUEOUS VAPOR FROM 21° TO 100° OF THE WET THERMOMETER; OR ELASTIC FORCE AT SATURATION.

Wet therm.	R. H.	F. V.	Wet therm.	R. H.	F. V.	Wet therm.	R. H.	F. V.	Wet therm.	R. H.	F. V.	Wet therm.	R. H.	F. V.
	pr. ct.	in.		pr. ct.	in.		pr. ct.	in.		pr. ct.	in		pr. ct.	in.
21°	100	.113	37°	100	.220	53°	100	.403	69°	100	.708	85°	100	1.203
22	100	.118	38	100	.229	54	100	.418	70	100	.733	86	100	1.242
23	100	.123	39	100	.238	55	100	.433	71	100	.759	87	100	1.282
24	100	.129	40	100	.248	56	100	.449	72	100	.784	88	100	1.323
25	100	.135	41	100	.257	57	100	.465	73	100	.811	89	100	1.366
26	100	.141	42	100	.267	58	100	.482	74	100	.839	90	100	1.409
27	100	.147	43	100	.278	59	100	.500	75	100	.868	91	100	1.454
28	100	.153	44	100	.288	60	100	.518	76	100	.897	92	100	1.500
29	100	.160	45	100	.299	61	100	.537	77	100	.927	93	100	1.548
30	100	.167	46	100	.311	62	100	.556	78	100	.958	94	100	1.597
31	100	.174	47	100	.323	63	100	.576	79	100	.990	95	100	1.647
32	100	.181	48	100	.335	64	100	.596	80	100	1 023	96	100	1.698
33	100	.188	49	100	.348	65	100	.617	81	100	1.057	97	100	1.751
34	100	.196	50	100	.361	66	100	.639	82	100	1.092	98	100	1.805
35	100	.204	51	100	.374	67	100	.662	83	100	1.128	99	100	1.860
36	100	.212	52	100	.388	68	100	.685	84	100	1.165	100	100	1.918

t—t'; Difference of Wet and Dry Bulb Thermometers.

t' Wet therm.	11° R. H.	11° F. V.	12° R. H.	12° F. V.	13° R. H.	13° F. V.	14° R. H	14° F. V.	15° R. H.	15° F. V.	16° R. H.	16° F. V	17° R. H.	17° F. V.	18° R. H.	18° F. V.	19° R. H.	19° F. V.	20° R. H.	20° F. V.
	pr. ct.	in.	pr. ct.	in.	pr. ct.	in.	pr. ct.	in.	pr. ct.	in.	pr. ct.	in.	pr. ct.	in.	pr. ct	in.	pr. ct.	in.	pr. ct.	in.
41°	29	.112	25	.099	20	.086	17	.073	13	.059	10	.046	7	.033	4	.020	1	.007		
42	30	.122	26	.109	22	.096	18	.082	15	.069	11	.055	8	.043	6	.030	3	.016	1	.003
43	32	.133	27	.119	23	.106	20	.093	16	.080	13	.066	10	.053	7	.040	5	.027	2	.013
44	33	.143	29	.130	25	.117	21	.104	18	.090	15	.077	12	.064	9	.050	7	.037	4	.024
45	34	.154	30	.141	26	.127	23	.114	19	.101	16	.088	13	.074	11	.061	8	.048	6	.035
46	35	.166	31	.152	28	.139	24	.126	21	.112	18	.099	15	.086	12	.072	10	.059	7	.046
47	37	.177	33	.164	29	.151	25	.138	22	.124	19	.111	16	.097	14	.084	11	.071	9	.058
48	38	.189	34	.176	30	.163	27	.149	24	.136	21	.123	18	.109	15	.096	12	.083	10	.070
49	39	.202	35	.189	31	.175	28	.162	25	.149	22	.135	19	.122	16	.109	14	.095	12	.082
50	40	.215	36	.201	33	.188	29	.175	26	.161	23	.148	20	.135	18	.121	15	.108	13	.095
51	41	.228	37	.215	34	.202	30	.188	27	.175	24	.161	22	.148	19	.135	17	.121	14	.108
52	42	.242	38	.228	35	.215	31	.202	28	.188	26	.175	23	.162	20	.149	18	.135	15	.122
53	43	.256	39	.243	36	.230	33	.216	30	.203	27	.189	24	.176	21	.163	19	.149	17	.136
54	44	.271	40	.258	37	.244	34	.231	31	.217	28	.204	25	.191	23	.178	20	.164	18	.151
55	45	.286	41	.273	38	.260	35	.246	32	.233	29	.219	26	.206	24	.193	21	.179	19	.166
56	46	.302	42	.289	39	.275	36	.262	33	.249	30	.235	27	.222	25	.209	22	.195	20	.182
57	46	.319	43	.305	40	.292	37	.278	34	.265	31	.251	28	.239	26	.225	24	.211	21	.198
58	47	.335	44	.322	41	.308	38	.295	35	.281	32	.268	29	.255	27	.241	25	.228	22	.214
59	48	.353	45	.339	41	.326	38	.313	36	.299	33	.286	30	.272	28	.258	26	.245	23	.232
60	49	.370	45	.357	42	.344	39	.330	36	.317	34	.303	31	.290	29	.276	27	.263	24	.250
61	50	.389	46	.376	43	.362	40	.349	37	.335	35	.322	32	.308	30	.295	27	.281	25	.268
62	50	.408	47	.395	44	.381	41	.368	38	.354	36	.341	33	.327	31	.314	28	.300	26	.287
63	51	.428	48	.415	45	.401	42	.388	39	.374	36	.361	34	.347	32	.334	29	.320	27	.307
64	52	.448	48	.435	45	.421	42	.408	40	.394	37	.381	35	.367	32	.354	30	.340	28	.327
65	52	.469	49	.456	46	.442	43	.429	40	.415	38	.402	35	.388	33	.375	31	.361	29	.348
66	53	.491	50	.477	47	.464	44	.450	41	.437	39	.423	36	.410	34	.396	32	.383	30	.369
67	53	.513	50	.499	47	.486	44	.472	42	.459	39	.445	36	.432	35	.418	33	.405	30	.391
68	54	.536	51	.522	48	.509	45	.495	43	.482	40	.468	37	.455	35	.441	33	.428	31	.414
69	55	.560	52	.546	49	.533	46	.519	43	.505	41	.492	38	.478	36	.465	34	.451	32	.438
70	55	.584	52	.571	49	.557	47	.543	44	.530	41	.516	39	.503	37	.489	35	.476	33	.462
71	56	.609	53	.596	50	.582	47	.569	45	.555	42	.542	39	.528	37	.514	35	.501	33	.487
72	56	.635	53	.622	50	.608	48	.594	45	.581	42	.567	40	.554	38	.540	36	.527	34	.513
73	57	.662	54	.648	51	.635	48	.621	46	.608	43	.594	40	.580	38	.567	36	.553	35	.540
74	57	.689	54	.676	51	.662	49	.649	47	.635	44	.621	41	.608	39	.594	37	.581	36	.567
75	58	.718	55	.704	52	.690	49	.677	47	.663	44	.649	42	.636	40	.622	37	.609	36	.595
76	58	.747	55	.733	52	.720	50	.706	48	.692	45	.679	43	.665	41	.652	38	.638	37	.624
77	58	.777	56	.764	53	.750	50	.736	48	.723	46	.709	44	.695	41	.682	39	.668	37	.654
78	59	.808	56	.794	53	.781	51	.767	49	.754	46	.740	44	.726	42	.713	40	.699	38	.685
79	59	.840	57	.826	54	.813	52	.799	49	.785	47	.772	45	.758	42	.744	40	.731	38	.717
80	60	.873	57	.859	55	.845	52	.832	50	.818	47	.804	45	.791	43	.777	41	.763	39	.750
81	60	.907	58	.893	55	.879	53	.866	50	.852	48	.838	46	.824	44	.811	42	.797	40	.783
82	61	.941	58	.928	55	.914	53	.900	51	.887	48	.873	46	.859	44	.846	42	.832	40	.818
83	61	.977	59	.964	56	.950	53	.936	51	.922	49	.909	47	.895	45	.881	43	.867	41	.854
84	62	1.014	59	1.000	56	.987	54	.973	51	.959	49	.945	47	.932	45	.918	43	.904	41	.890
85	62	1.052	59	1.038	57	1.024	54	1.011	52	.997	50	.983	48	.969	45	.956	44	.942	42	.928

Abstract of the discussion of the Hygrometric Formulas.

In the formula of the psychrometer given by August and discussed by Regnault there enter,—

w, the weight of the thin layer of air adjacent to the bulb and supposed dry, at 760 mm. (29.921 inches) pressure.
h, the height of the barometer.
t, the temperature of the surrounding air.
t', the temperature of the wet bulb.
f, elastic force at saturation with temperature t.
f', elastic force at saturation with temperature t'.
x, the term sought, or the relative force at the time.

1. The weight of the air dry (the thin layer).
2. The vapor in this air; that before contact, and that evaporated.
3. The quantity of heat abandoned by the air in changing from dry to wet-bulb temperatures.
4. The quantity so abandoned by the aqueous vapor.
5. Finally; with the latent heat of aqueous vapor between the temperatures t and t', giving the heat absorbed by the vapor which is formed.

Equalizing the last quantity with the preceding two, or the heat abandoned with the heat absorbed, we have;

$$x=\frac{1+\frac{\text{sp. h. of dry air}}{\text{(dens. vap.) (lat. h. vap.)}}\text{(diff. wet and dry bulb)}}{1+\frac{\text{sp. h. vap.}}{\text{lat. h. vap.}}\text{(diff. wet and dry bulb)}}\left(\begin{matrix}\text{force of vap. at sat.}\\ \text{of wet bulb.}\end{matrix}\right)-\left(\begin{matrix}\text{same quantities mult'd}\\ \text{by height of bar.}\end{matrix}\right)$$

Numerically we have;

$\gamma =$ spec. heat of dry air $= 0.2669$ [August, from exp'ts by Laroche and Berard.]
$\kappa =$ sp. h. of aqueous vapor $= 0.2659$ (from the same).
$\delta =$ density of aq. vap. $= 0.6235$ (air being 1;) [Gay Lussac.]
$\lambda =$ latent heat of aq. vap. $= 640 - t'$ (centig.) [August, law of Watt.]

$$x=\frac{1+\frac{\gamma}{\delta\lambda}(t-t')}{1+\frac{\kappa}{\lambda}(t-t')}f'-\frac{\frac{\gamma}{\delta\lambda}(t-t')}{1+\frac{\kappa}{\lambda}(t-t')}h.$$

Substituting, and neglecting very small quantities, M. August obtained;

$$x=f'-\frac{0.568\ (t-t')}{640-t'}h.$$

Modifying the numerical elements we suppose; (Regnault)

$\delta =$ density of aq. vap. $= 0.622$.
$\lambda =$ lat. h. vapor $= 610 - t'$ (centig.)
$= 1130 - t'$ (Fahr.)

Supposing specific heat of air and vapor equal, and again substituting, we have;

$$x=\frac{1+\frac{0.2669}{0.622\,.\,\lambda}(t-t')}{1+\frac{0.2669}{\lambda}(t-t')}f'-\frac{\frac{0.2669}{0.622\,.\,\lambda}(t-t')}{1+\frac{0.2669}{\lambda}(t-t')}h.$$

Reducing and neglecting small quantities;

$$x=f'-\frac{0.429\ (t-t')}{610-t'}h.\quad \text{(Centig.)}$$

$$\text{and } x=f'-\frac{0.429\ (t-t')}{1130-t'}h.\quad \text{(Fahr.)}$$

Subsequently Regnault modifies the numerical value (0.429) resulting from the specific heat and density of aqueous vapor of the formula; determining experimentally that it gives too great an elastic force for x. Substituting the co-efficient 0.480 for 0.429, the coincidence between the results calculated and observed is complete for all fractions of saturation above 0.40.

To construct from these elements a scale in Fahrenheit and English inches we have to change the numerical value of the latent heat of aqueous vapor, $610 - t'$, to $1130 - t'$; and to substitute the value of h in inches simply. For f' an absolute translation of Regnault's table of elastic forces at saturation is required.

XIX. CLIMATE OF THE NORTHWESTERN DISTRICTS.

The great practical interest now felt in the northwestern areas of this continent requires that some distinct reference to their climate should be made, and as it has been necessary to compress some of the scientific analyses in other cases, it is thought that the space at first intended for the discussion of the vertical range of vegetation on this continent, should be occupied in a manner more acceptable to the general reader. The whole climatological discussion bears more or less directly on this point throughout, but a compact statement of the advantages belonging to this territory, and having their basis in climate, is quite desirable.

The assertion may at first appear unwarranted, but it is demonstrable that an area, not inferior in size to the whole United States east of the Mississippi, now almost wholly unoccupied, lies west of the 98th meridian and above the 43d parallel, which is perfectly adapted to the fullest occupation by cultivated nations. The west and north of Europe are there reproduced, with the exceptions caused by vertical configuration only; and important as this feature of configuration is in giving us a lofty mountain boundary on the west, we may charge much of disadvantage to that account and still leave all that is here claimed—an immense and yet unmeasured capacity for occupation and expansion. By reference to the illustration of the distribution of heat we see that the cold at the north of the great lakes does not represent the same latitude farther west, and that beyond them the thermal lines rise as high in latitude, in most cases, as at the west of Europe. Central Russia, Germany, the Baltic districts and the British Islands, are all reproduced in the general structure, though the exceptions here fall against the advantage, while there they favor it, through the immediate influence of the Gulf Stream.

The parallel in regard to the advancement of American States here may be drawn with the period of the earliest trans-Alpine Roman expansion, when Gaul, Scandinavia, and Britain were regarded as inhospitable regions, fit only for barbarian occupation. The enlightened nations then occupied the latitudes near the Mediterranean, and the richer northern and western countries were unopened and unknown.

Climate is indisputably the decisive condition, and when we find the isothermal of 60° for the summer rising on the interior American plains to the 61st parallel, or fully as high as its average position for Europe, it is impossible to doubt the existence of favorable climates over vast areas now unoccupied. This favorable comparison may be traced for the winter also, and in the averages for the year. The exceptional cold of the mountain plateaus, and of the coast below the 43d parallel, masks the advantage more or less to those who approach these areas from the western part of the central States, and from the coast of California; but though the distinct mountain ranges remain high at the north, the width of their base, or of the plateau from which they rise, is much less than at the 42d parallel. The elevated tracts are of less extent, and the proportion of cultivable surface is far greater.

It will be seen that the thermal lines for each season are thrown northward farther, on passing Lake Superior westward, in the charts of this work than in those of the Military Report prepared by the author. At the time those were drawn the number of observations beyond the limits of the United States was so small that the full expression was not given to the statistics then used, in the fear that some correction would ultimately be found to apply to them, reducing the extreme northward curvatures they indicated. But a farther collection and comparison warrants the positions now given to the thermal lines, placing them farther northward than before, and extending them in a course due northwest from Lake Superior to the 58th parallel. For the extreme seasons, winter and summer, this accurate diagonal extension of the thermal lines across the areas of latitude and longitude is very striking. The buffalo winter on the upper Athabasca at least as safely as in the latitude of St. Paul's, Minnesota, and the spring opens at nearly the same time along the immense line of plains from St. Paul's to Mackenzie's River.

The quantity of rain is not less important than the measure of heat to all the purposes of occupation, and for the plains east of the Rocky Mountains there may reasonably be some doubt as to the sufficiency; and doubts on the point whether the desert belt of lower latitudes is prolonged to the northern limit of the plains. If the lower deserts are due to the altitude and mass of the mountains simply, it would be natural to infer their existence along the whole line where the Rocky Mountains run parallel and retain their altitude; but the dry areas are evidently due to other causes primarily, and they are not found above the 47th parallel in fact. It is decisive of the general question of sufficiency of rain to find the entire surface of the upper plains either well grassed or well wooded, and recent information on these points

almost warrants the assertion that there are no barren tracts of consequence after we pass the Bad Lands, and the *Coteaus* of the Missouri. Many portions of these plains are known to be peculiarly rich in grasses, and probably the finest tracts lie along the eastern base of the mountains, in positions corresponding to the most desert-like of the plains at the south. The higher latitudes certainly differ widely from the plains which stretch from the Platte southward to the Llano Estacado of Texas, and none of the references made to them by residents or travellers indicate desert characteristics. Buffalo are far more abundant on the northern plains, and they remain through the winter at their extreme border, taking shelter in the belts of woodland on the upper Athabasca and Peace rivers. Grassy savannas like these necessarily imply an adequate supply of rain, and there can be no doubt that the correspondence with the European plains in like geographical position—those of eastern Germany and Russia—is quite complete in this respect. If a difference exists it is in favor of the American plains, which have a greater proportion of surface waters, both as lakes and rivers.

For the higher latitudes the distribution of rain differs radically from that at the south, and our route to New Mexico traverses the districts corresponding to the Asiatic plains, and not to those of Europe. In the one case a range of mountains has little effect to render the adjacent plains arid, while in the other the most extreme contrasts are presented at the opposite mountain bases. We greatly undervalue the central districts here by deriving our ideas from the middle latitudes, or those which lie due west of the richest portions of the Mississippi valley. The analogies of continental distribution of rain clearly show that the want of rain in lower latitudes is not mainly the consequence of vertical configuration, it is only controlled locally by these features so much as to render the immediate distribution variable, where the whole exterior quantity is greatly deficient. A reference to the general chart of rain distribution will convey a forcible idea of the comparisons and general analogies, which warrant the opinions here expressed, in regard to the great districts from which we have yet no absolute measurements of the quantity of rain. The northwestern coast of this continent is even more profusely rainy than any part of the northwest of Europe, and the configuration is less sharply interrupted along the coast north of Puget's Sound than it is south of that line. If positive evidence were wanting in regard to any part of the interior plains above the 45th parallel, it could not reasonably be inferred that they were wanting in an adequate supply of atmospheric moisture.

With these facts of climatological capacity established, as the whole

tenor and significance of American research on this point clearly shows, it may be more easy to understand the descriptions of those who have travelled there, and to connect the somewhat meagre accounts yet written. It is most surprising that so little is known of the great Islands, and the long line of coast from Puget's Sound to Sitka, ample as its resources must be even for recruiting the transient commerce of the Pacific, independent of its immense intrinsic value. To the region bordering the northern Pacific the finest maritime positions belong throughout its entire extent, and no part of the west of Europe exceeds it in the advantages of equable climate, fertile soil, and commercial accessibility of the coast. The western slope of the Rocky Mountain system may be included as a part of this maritime region, embracing an immense area from the 45th to the 60th parallel, and five degrees of longitude in width. The cultivable surface of this district cannot be much less than *three hundred thousand square miles.*

Next is the area of the plains east of the Rocky Mountains, not less remarkable than the first for the absence of attention heretofore given to its intrinsic value as a productive and cultivable region, within easy reach of emigration. This is a wedge-shaped tract, ten degrees of longitude in width at its base along the 47th parallel, inclined northwestward to conform to the trend of the Rocky Mountains, and terminating not far from the 60th parallel in a narrow line, which still extends along the Mackenzie for three or four degrees of latitude, in a climate barely tolerable. Lord Selkirk begun his efforts at colonization here as early as 1805, and from personal knowledge he then claimed for this tract a capacity to support thirty millions of inhabitants. All the grains of the cool temperate latitudes are produced abundantly—Indian corn may be grown on both branches of the Saskatchawan, and the grass of the plains is singularly abundant and rich. Not only in the earliest period of exploration of these plains, but now, they are the great resort for buffalo herds, which, with the domestic herds, and the horses of the Indians and the colonists, remain on them and at their woodland borders through the year. The simple fact of the presence of these vast herds of wild cattle on plains at so high a latitude is ample proof of the climatological and productive capacity of the country. Of these plains and their woodland borders the valuable surface measures fully *five hundred thousand square miles.*

In various parts of the present work references have been made to the leading incidents of natural capacity and of actual growth in the northwestern districts. It is not necessary to repeat these here, and the present purpose is only to direct attention to the development in that quarter, as one offering clearly the greatest field in which natural

advantages await the use of civilized nations. The reason for most of the previous and present neglect of this region lies in mistaken views of its climate, and the peculiarities of much of the Lake Superior district are such as to perpetuate the mistake. With the unusual severity of the last two or three winters there, it appears incredible that the country at the west, rising toward the Rocky Mountains, should be less severe. But the vast plain rises very little. Fort Union is but 2000 feet above the sea, and Fort Benton but 2600, though 15° of longitude due west of the plain at the sources of the Mississippi at 1500 feet. Much of it declines in altitude northwestward, indeed, toward the northern lake basins and Hudson's Bay. The increase of temperature westward is quite as rapid as it is southward to New Mexico, and the Pacific borders at the 50th parallel are milder in winter than Santa Fè. In every condition forming the basis of national wealth, the continental mass lying westward and northwestward from Lake Superior is far more valuable than the interior in lower latitudes, of which Salt Lake and Upper New Mexico are the prominent known districts.

The history of this northwestern district has unusual interest, also, though the details are meagre. French traders ranged the fertile plains of Red River and the Saskatchawan nearly two centuries since, and the rich trade in furs and peltries has for so many years been constantly gathered from the surrounding tracts through that as a central area. This occupation was coeval with the Spanish occupation of New Mexico and California, and but for the pernicious views entailed by the fur traffic as to the necessity of preserving it as a wilderness, it would long since have been opened to colonization. The Hudson's Bay and Northwest companies had a gigantic contest for possession after the French had given way to British dominion in Canada, and both these companies at last concentrated their strength on efforts to preserve the wilderness, and to crush the infant colony of Lord Selkirk.

The whole space here designated the Northwest is, however, the joint possession of the United States and Great Britain, not only in territorial title, but in all the incidents of development. Its commercial and industrial capacity is gigantic, and one which it is the highest interest of both governments to bring out at the earliest moment.

The illustration of the summer and winter climates for the country north of the 50th parallel is given, though with less fulness than could be desired, on the Isothermal and Rain Charts for the temperate latitudes of both continents. The allusions here made may be traced there in a general way, but a map on a more ample scale, representing the now unknown plains of the Yellowstone and the southern Saskatchawan, and the equally important Pacific districts north of

Vancouver's Island, and with a full geographical detail, where so much is now vaguely placed, is much to be desired. For the small number of points observed above the 45th parallel, the statistics are very well distributed to define the climate. The points on the Missouri river, Fort Union and Fort Benton, Fort Owen in the first valley at the passage of the Rocky Mountains here, Kooskooskia in the plain of the Columbia, and the several Military Posts in Oregon and on Puget's Sound, form an ample representation beyond and in the latitude of the well known posts of the vicinity of Lake Superior. From this last point of departure, also, in a line northwestward, there are Fort William, Pembina, Fort Garry, and the fine series of observations at Norway House near the north end of Lake Winipeg, as the first group. Then Carlton House, Cumberland House, Edmonton House, Fort Liard, Fort Simpson, Sitka, and Yukon,—forming a crescent along the milder portions, and beyond which the still better observed points at Lake Athabasca, Great Bear Lake, and Hudson's Bay, confirm the distribution so as to leave no doubt of its general reliability.

The conditions existing in this immense area deserve a distinct treatment, and particularly the importance of the great channel of access through Lake Superior attaches the highest interest to the definition of its peculiar climate. In severe winters the most formidable ice barriers are interposed over a portion of its surface, as the ice remains late and in large fields and masses at the eastern end of Lake Erie in the same cases—in both lakes the western and larger portions being free from obstructions at a date much earlier.

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